GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

NORTH - WESTERN MANITOBA

WITH PORTIONS OF THE ADJACENT DISTRICTS OF

ASSINIBOIA AND SASKATCHEWAN

BY

J. B. TYRRELL, M.A., B.Sc., F.G.S.,

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1892

To Alfred R. C. Selwyn, C.M.G., LL.D., F.R.S., &c.,
Director and Deputy Head,
Geological Survey of Canada.

Sir,—I beg to present herewith my report on North-western Manitoba, and portions of the adjacent Districts of Assiniboia and Saskatchewan, accompanied by two copies of a map on the scale of eight miles to one inch, one showing the geology of the region, and the other the distribution and character of the forests.

The collections made during the course of the exploration have for the most part been described in other reports and papers. For gratuitous assistance in the description of these collections we are indebted to Dr. D. Rüst, of Hanover, Germany; Dr. H. A. Nicholson, of Aberdeen, Scotland; Prof. T. Rupert Jones, of London, England; Sir William Dawson, Prof. D. P. Penhallow and Prof. B. J. Harrington, of McGill College, Montreal.

We are also indebted to the various officers of the Hudson's Bay Company for much assistance rendered during the course of the exploration, but especially to Mr. David Armitt, of Manitoba House, who did everything in his power to promote the welfare of the expedition.

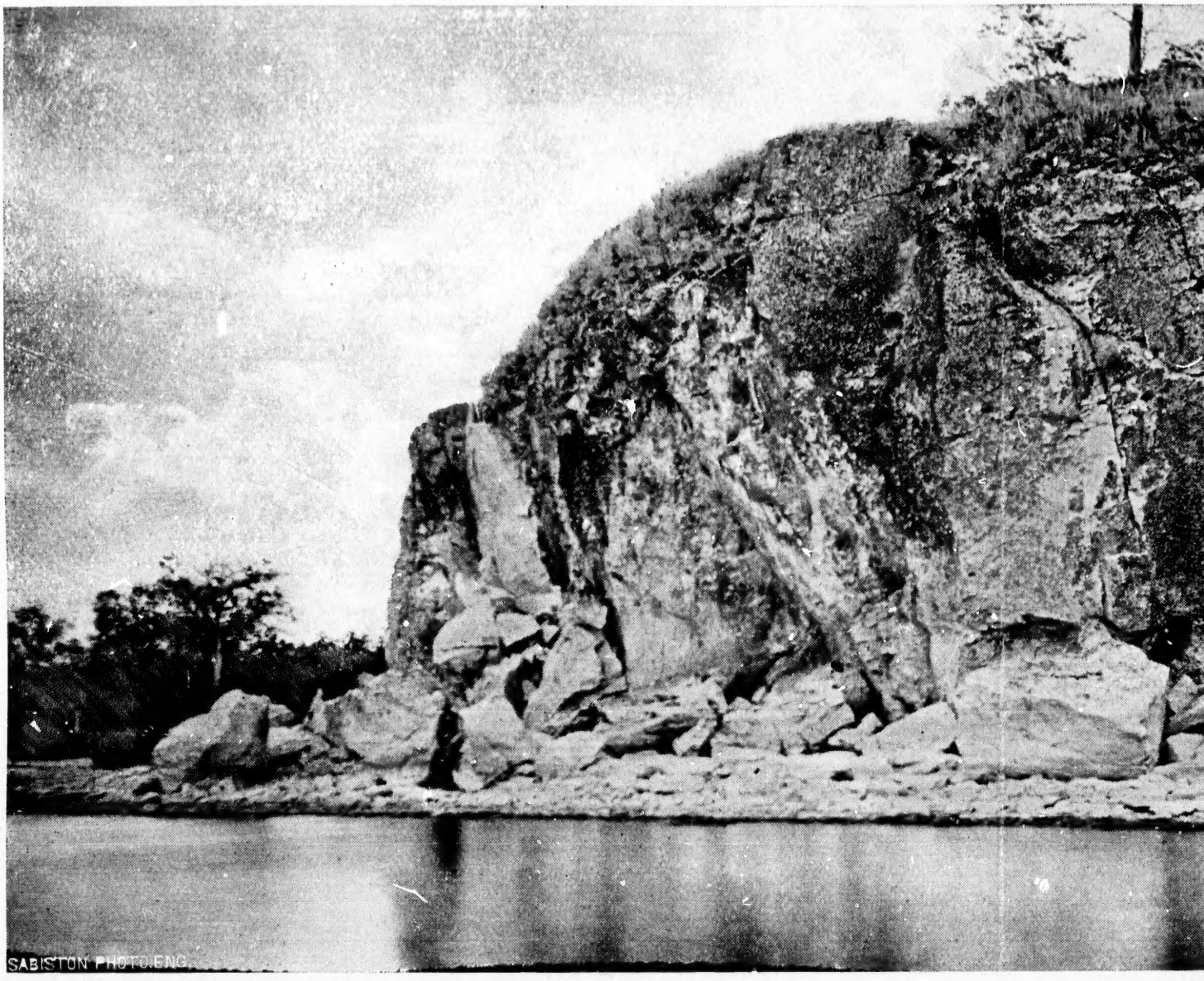
I have the honour to be, sir,

Your obedient servant,

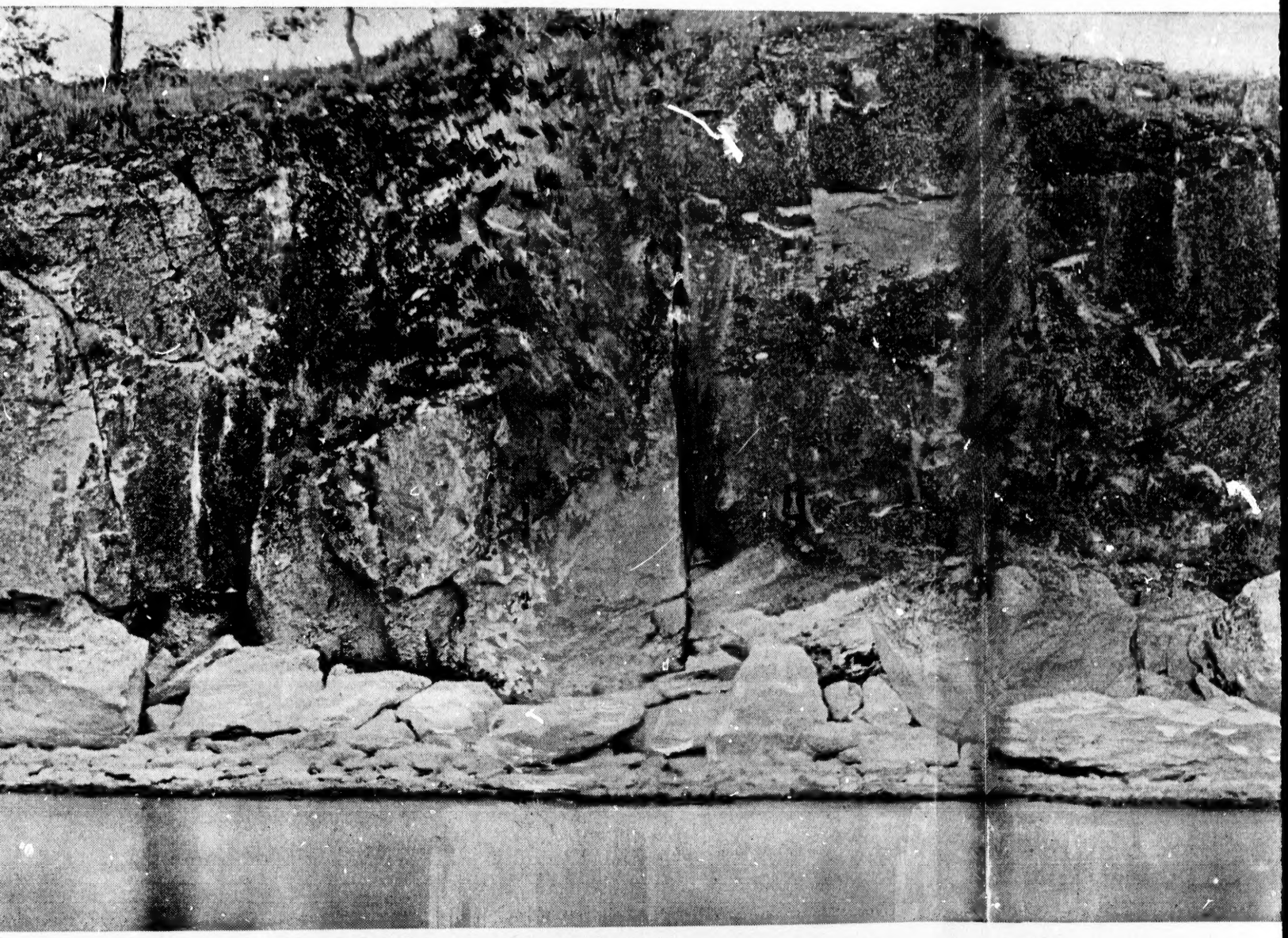
J. B. TYRRELL.

Geological Survey Office, 6th June, 1892.

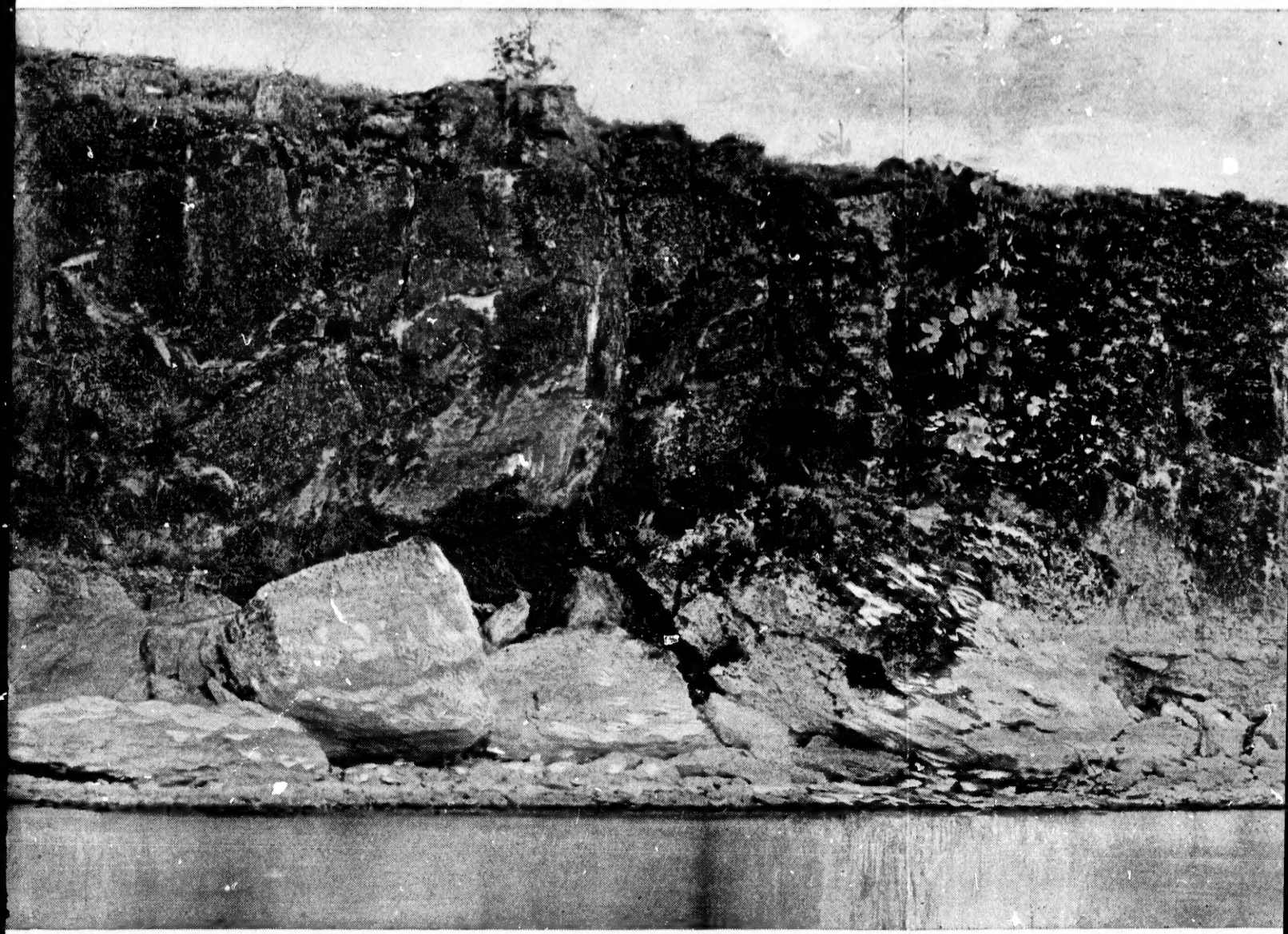
NOTE.—The bearings throughout this report are given with reference to the true meridian.



J. B. Tyrrell, Photo., Ju'y 25, 1889.



CLIFF OF MIDDLE DEVONIAN DOLOMITE (STR
ON AN ISLAND NORTH OF WHITEAVES POINT, DAWSON BAY, LAKE W



NIAN DOLOMITE (STRINGOCEPHALUS ZONE)
AWSON BAY, LAKE WINNIPEGOSIS. Lat. 52° 51′ 40″ N., Long. 100° 40′ W.

NORTH-WESTERN MANITOBA

WITH PORTIONS OF THE DISTRICTS OF

ASSINIBOIA AND SASKATCHEWAN

INTRODUCTION.

Date of exploration.

The present report, with the accompanying maps, is the result of explorations carried out during the summers of 1887 and 1889, and portions of those of 1888 and 1890.

Preliminary report.

On account of the magnificent resources of this country in dairying, lumbering and agriculture, and also on account of the long continued ill-health of the writer caused by an attack of typhoid fever contracted in the northern part of Lake Manitoba, it was thought advisable to publish a preliminary description of the region in the Annual Report Geological Survey, vol. III., in which a few of its main characteristics were commented on.

Assistance.

Throughout the progress of the survey, Mr. D. B. Dowling, B.A.Sc., has acted continuously as my assistant and has performed a considerable portion of the topographical work that it was found absolutely necessary to prosecute in order to designate intelligently the geological features of this hitherto almost unknown region. To him is also due the credit for any excellence that the maps possess from a cartographical stand-point. The projection was laid down by Mr. Scott Barlow, chief draughtsman, and the proofs were carefully inspected by him.

Contour lines

In the preparation of the map, it has been found much more satisfactory to represent differences of elevation by contour lines, rather than by hachuring as has been customary up to the present in the maps published by this department, since by this method the character of the escarpment running north-north-westward through the province of Manitoba can be beautifully brought out. On the other hand, it has been impossible thus to represent many of the steep, but comparatively low slopes.

Maps.

As a basis for the preparation of the present map the surveys made by the Dominion Lands Branch of the Department of the Interior have been used wherever practicable. These include surveys of townships and township outlines in the southern portion, all of which are marked in full lines; the western boundary of the province of Manitoba as far north as the north side of township 36; a meridian township outline between ranges 18 and 19 on the First System of Survey, run on the ice across Lake Winnipegosis to Cedar Lake; a traverse survey of Lake Manitoba (corrected by transverse lines at several points); a traverse survey of Lake Winnipegosis from Meadow Portage around the west shore to the mouth of Overflowing River, and surveys of Shoal River, Swan Lake, and Swan and Overflowing Rivers for a few miles above their mouths; a survey of the Saskatchewan River (corrected for longitude by connecting it with the meridian line running southward across Lake Winnipegosis). The surveys of the old line of the Canadian Pacific Railway have been of much value, especially in furnishing reliable bases of elevation. The Manitoba and North-western Railway has furnished similar information for the south-west corner of the sheet. Besides these lines, surveys of Waterhen River, and Meadow and Mossy Portages were made in connection with the Canadian Pacific survey. Indian reserves have been incorporated throughout, as well as several surveys of timber limits in the northern portion of the Duck Mountains.

The following statement of the surveys performed during the course of the present exploration is essentially an abridgement from the Summary Reports of the Director in the "Annual Reports" of the Geological Survey Department, vols. III. and IV.

Exploration, 1887.

Starting from Brandon on the 15th of July, 1887, we drove northward to Strathclair, and thence made an odometer survey of the trail up the Little Saskatchewan River to its source in Lake Audet, across the summit of Riding Mountain and down the Vermilion River to Lake Dauphin. From this trail, paced surveys were made of the beds of Ochre River and Edwards Creek, the banks of these streams being either too swampy or too much obstructed by fallen timber to admit of following them even on foot.

Lake Dauphin Plain.

An odometer survey was then made northward across Wilson River to Valley River, a track survey at the same time being made of Wilson River and its vicinity. North of Valley River one of the rounded gravel ridges, known to the Indians as "Pitching Ridges," was followed, first with a buckboard and odometer, and afterwards on horseback as far as Fork River, a fairly accurate sketch-map being at the same

time made of the eastern face of Duck Mountain. Finding that progress would be very slow north of Fork River, we returned to Valley River and made an odometer survey of the cart trail leading westward along this stream, reaching Shell River through the deep glacial valley that separates the Duck from the Riding Mountain. From Shell River the trail was followed and surveyed over the high ground southward to the village of Russell, a terminus of one of the branches of the Manitoba and North-western Railway. From Russell, a similar survey was conducted across Silver, Bird Tail and Arrow Creeks to Shoal Lake, and thence to Little Saskatchewan River, returning by a more northern route to the point of starting.

Shell River.

From Russell we proceeded northward with buckboard and carts to Assessippi, on Shell River, from which point the vehicles were sent round to meet me higher up the river, while with saddle and packhorses I examined the lower part of the valley, and rejoined the carts about the south line of township 26. We then continued up Shell River to within three miles of the confluence of the north and east branches, generally in the bottom of the wide, deep valley, but sometimes where it was impossible, without great delay, to ford the stream, we were obliged to climb to the top of the bank. On the way, however, we left Shell River for a time and turned eastward on an Indian cart trail to Angling Lakes, where Coté's band of Indians have several houses in which they spend the winter, being here in the centre of their hunting grounds. From this village, then quite deserted, a track survey was made of the stream that flows southward out of the largest and most easterly of the Angling Lakes till it was found to flow into the valley that separates the Duck from the Riding Mountain. It was found to be the main branch of Valley River. Two pack trails leading northward from the Indian village were also examined, one being found to lead up the east branch of Valley River to its source, and the other to Gull Lake which belongs to the drainage area of Shell River.

Angling Lakes.

Returning to this latter river, we were obliged to leave the carts at a point three miles below the confluence of the north and east branches, and to use packhorses in continuing the survey towards the sources of some of the small streams tributary to the main river. Returning to the carts we followed and surveyed an Indian cart trail westward across Big Boggy and Little Boggy Creeks, till it joined the old Pelly cart trail at the Indian village on Coté's Reserve. We then followed and located the latter trail northward to Fort Pelly, where we arrived on the 22nd of September.

Swan River.

Having here obtained sufficient supplies to last till the end of the season, we followed a cart trail to the north-east, keeping south of Swan River for about forty miles, or till we reached the "Square Plain," making an odometer survey throughout the distance. I, however, branched off from this trail, and with packhorses followed a trail up Rolling River, till the stream became very small and was flowing in a shallow valley through a country that appeared to be one interminable swamp. As the country was impassable for horses, I returned and made a paced survey down the bed of the stream to a short distance below the crossing of the old location of the Canadian Pacific Railway, where the river again flows in a defined but winding channel through a marshy, level tract of country.

Duck Mountain.

Returning to Square Plain, Swan River was crossed and followed on its northern bank down to the mouth of Oak Creek, where the carts were again left, and with pack and saddle horses a track survey was made around the north end of Duck Mountain, following, during part of the distance, conspicuous gravel ridges that extend along the eastern face of the escarpment, at least as far north as the valley of Swan River. In returning, the north-east point of the Duck Mountain was crossed, and also the head-waters of North and South Duck Rivers and Pine River. Then passing around the north end of Big Lake, in which Rolling River takes its rise, the head of Favell River was reached. This river was then followed on a northward course to near its junction with Rolling River, whence we returned to the carts at the mouth of Oak Creek.

While I was engaged as above described, Mr. Dowling was making pace and track surveys of Swan River and of the country lying north of it in the vicinity of the camp.

Swan River Trail.

Below Oak Creek an odometer survey was made of the trail down to Swan Lake, and the river was followed on foot in many places, where there was any possibility of exposures of the underlying rocks being met with. From Swan Lake the party returned to Fort Pelly by the old Hudson Bay Company's cart trail on the north side of Swan River, at the same time making an examination of the southern face of Thunder Hill.

The village of Russell was reached and the season's work completed on the seventh of November.

Barometer readings.

Readings were taken regularly three times a day from a mercurial barometer, and numerous intermediate readings were taken from two aneroids. These were compared with readings taken from a standard mercurial at Minnedosa, the height of the cistern of which is 1,689 feet. Known points were also taken along the old Canadian Pacific

railway survey line, and barometer readings at these points were compared with simultaneous readings at many surrounding places.

Exploration, 1888.

On the 13th of June, 1888, I left Winnipeg for Portage la Prairie, where Mr. W. R. Baker, General Superintendent of the Manitoba and North-western Railway, kindly ordered a railway velocipede to be placed at my disposal. With its assistance all the cuttings on the railway between Minnedosa and Langenburg were examined, as well as the material thrown out of the wells at and between the different stations.

Returning from Minnedosa to Westbourne we paddled down White Mud River to Totogen, and from there coasted along the west side of Lake Manitoba to Manitoba House The east side of the lake was next examined from Manitoba House to Fairford, and the Fairford River was descended to its mouth in Lake St. Martin.

Lake St. Martin.

A survey was made of this latter lake by Mr. Dowling with a compass and floating boat-log, while the writer travelled on foot into the wooded country to the west of the lake for the purpose of examining and locating a reported deposit of gypsum, after which a careful geological examination was made of the shores of the lake itself.

Returning to Lake Manitoba, its north shore was examined, and any outlying islands were surveyed, as far as the mouth of Waterhen River, and this river was explored up to Waterhen Lake.

From Waterhen Lake the writer returned to Manitoba House, and the next eighteen days were spent in company with Mr. J. F. Whiteaves, Palæontologist of the Geological Survey Department, in making a full collection of fossils from the exposures of Devonian rocks around the shores of Lake Manitoba.

Lake Winnipegosis.

In the mean time, Mr. Dowling surveyed the east shore of Lake Winnipegosis with a compass and micrometer as far as Mossy Portage, and the north shore with a transit and micrometer from the meridian outline near Mossy Portage to the mouth of Overflowing River, there connecting with the traverse of the west side of the lake made by the Dominion Lands Branch of the Department of the Interior two years before.

He next surveyed with compass and micrometer the Overflowing River for thirty-seven miles up from its mouth, the Red Deer River up to the lake, which was found to have an area of a hundred square miles, and the river for twenty-two miles above the lake. He also connected the final point of the Dominion Lands survey of the Swan River with the chain survey of the higher parts of the river on the south-east side of two Indian reserves now abandoned. He also made a survey of many of the islands in Lake Winnipegosis.

Exploration, 1889.

In the spring of 1889 the rivers St. Martin (Little Saskatchewan) and Fairford were ascended from Lake Winnipeg to Lake Manitoba, and Manitoba House was reached on the evening of the 8th of June.

From Manitoba House the lake was crossed to Crane River Narrows, where lines were run to locate some islands more exactly, and to connect the surveys of the opposite sides of the lake. The Waterhen River was ascended to Lake Winnipegosis and the south shore of this lake examined to the mouth of Mossy River, and at the same time a survey was made of Snake Island, and the other islands in its vicinity.

Mossy River.

A micrometer and compass survey was made of Mossy River, and the shores of Lake Dauphin were run in with the floating boat-log.

Lake Winnipegosis.

From Mossy River, the shore of Lake Winnipegosis was closely followed and examined to the mouth of Red Deer River and surveys were made of all the adjoining islands. Shoal River was then ascended to Swan Lake, and surveys were made of the islands in this lake.

Porcupine Mountain.

From the west side of Swan Lake an examination was undertaken along the foot of the Porcupine Mountain to Kematch River where a good section of the Niobrara and Benton beds was obtained; meanwhile Mr. Dowling crossed to Bell River, and ascended it to the summit of the mountain, also obtaining a section of the Cretaceous shale and the overlying drift. North of Porcupine Mountain Red Deer River was ascended in canoes to Red Deer Lake. There, horses were obtained from a small band of Indians living at the west end of the lake, and with two men I struck back to Armitt River at the foot of the mountain. From the west bank of this stream two gravel ridges were followed alternately, to near the mouth of the Etoimami River, where they merge into an extensive sandy delta-plain. An old trail was then followed down the north side of Red Deer River back to the lake.

From the mouth of Red Deer River an examination was made of the north and east shores of Lake Winnipegosis, a pace survey was made of the western Mossy Portage, while the eastern Mossy Portage was also carefully examined.

Waterhen Lake.

From Pine Creek Mr. Dowling returned with the boat to Manitoba House, stopping on the way to make a survey of Waterhen Lake with a compass and floating boat-log. The writer left Pine Creek with a horse and cart, and made an odometer survey of the trail back to a small new Indian village on one of the pitching ridges. From there the ridge was followed north to Duck River, and the deep gorge of North Pine River was discovered and examined. From the Indian village an odometer survey was made southward to the Dauphin settlement, and thence eastward through wooded country to Manitoba House.

Exploration, 1890.

In the early summer of 1890 a canoe traverse was made of the Assiniboine River southward from Fort Pelly to Portage la Prairie, and immediately afterwards a survey of the islands and south shore of Cedar Lake was made with a compass and floating boat-log, and the Saskatchewan River was examined from Cedar Lake down to its mouth. At the same time Mr. Dowling examined a small area, hitherto unexplored, on the eastern face of the Riding Mountain south of Lake Dauphin.

The plateau on the summit of Porcupine Mountain was not examined, but its topography has been dotted in from plans and verbal information received from Sakewékochin, John Beardy and Peter More, three Indians living near Swan Lake who hunt and trap in that area.

Fossils.

During the course of the exploration the fossil fauna of western Canada has been very greatly enriched both by the discovery of new species and by the finding of many previously known species which have not before been met with on this continent. Most of these have been identified or described by Mr. J. F. Whiteaves, Palæontologist of this department. The fossil plants have been kindly determined by Sir William Dawson and Professor D. P. Penhallow, of Montreal; the Radiolaria by Dr. D. Rüst, of Hanover, Germany; the Stromatoporoids by Dr. H. A. Nicholson, of Aberdeen, Scotland; the Ostracoda by Professor T. Rupert Jones, of London, England; and a Cretaceous insect by Professor S. H. Scudder, of Cambridge, Mass., U.S. Specimens of brine from all the principal brine springs in the district were collected and have been analysed by Mr. G. Christian Hoffmann, Chemist of this department; while Professor B. J. Harrington, of Montreal, has kindly analysed the fossil resin collected on the shore of Cedar Lake.

Photographs.

More than two hundred photographs have been taken of places and features of especial interest throughout the region.

HISTORICAL SKETCH.

Secluded position.

North-western Manitoba has, up to the present time, remained comparatively unknown, for since the early part of the present century it has been off the main line of travel either to the Great Plains or to the Athabasca Region. Prior to A.D. 1806, however, the Swan and Red Deer rivers were main channels of the trade of the North-west Company with the Indians of the Plains, and a good cart trail is stated to have existed along the north bank of the latter river through what is now dense poplar forest. Also for many years after the above date Fort Pelly was one of the chief trading posts of the Hudson's Bay Company, and boats of from three to four tons burden annually descended the Swan River, carrying the furs there collected to York Factory on Hudson's Bay.

The following are among the more important recorded explorations that have been made in the region under consideration up to date :

Verendrye, 1739.

Lake Manitoba was first discovered by Chevalier de la Verendrye, who in April, 1739, was sent by his father, Sieur de la Verendrye from Fort la Reine at Portage la Prairie, to look for suitable places to construct forts on Lake des Prairies (Manitoba) and the lower portion of River Paskoiac (Saskatchewan) and to examine the northern end of Lake Winnipeg in order to intercept the trade with the English at Hudson's Bay. Two years later, in October, 1741, another party was sent by Sieur de la Verendrye, under the Chevalier's eldest brother Pierre, to build Forts Dauphin and Bourbon in the district already explored.*

David Thompson, 1797.

In September, 1797, David Thompson, the distinguished geographer of North-western America, crossed Lake Winnipeg from the mouth of Winnipeg River, ascended Dauphin (St. Martin's) River, and entered Manito (Manitoba) Lake. This lake was crossed, the goods were carried across Meadow Portage, and he proceeded to the mouth of the Little Dauphin (Mossy) River. He then traversed Lake Winnipegosis, ascended Shoal River to Swan Lake, and ascended Swan River a short distance to the old fort of the North-west Company on the broad alluvial flat on the north bank of the stream. Here he left his birch canoes and taking horses rode up the valley of Swan River to the trading post on Snake Creek, crossing on his way a wide sandy plain on which he states that "the buffalo sometimes feed in winter." From the Snake Creek Post

*Report on Canadian Archives, 1889, p. 27. Memoire du Sieur de la Verendrye, in Mémoire et Documents originaux, recueillis et publiés par Pierre Margry. Paris, 1889, pp. 591 & 594.

he turned south to the Assiniboine River, the valley of which he followed to a trading post six miles below the mouth of Little Boggy Creek. He next surveyed the upper waters of the Assiniboine River, after which he set out on his winter journey to the Mandan villages on the Missouri. Mr. Thompson's map, on the scale of about thirteen miles to the inch, is in the possession of the Crown Lands Department of the province of Ontario.*

Alex. Henry, 1800.

Alexander Henry, who was afterwards drowned at the mouth of the Columbia River in 1814, spent the winter of 1799–1800 at Fort Dauphin on the lake of the same name, and in 1804, he made a winter journey from Portage la Prairie across Lake Manitoba to Manitoba House.†

D. W. Harmon, 1800.

In the year 1800 Daniel Williams Harmon, at that time a clerk, and afterwards a partner in the North-west Company, ascended St. Martin's River, crossed Lakes Manitoba and Winnipegosis and ascended the Swan River to the company's trading post. During the winters of 1800–1804 he often travelled up the Swan River valley with a dog team. He speaks of the soil being rich, of there being a garden at the fort, and of salt springs in the vicinity from which salt was obtained.‡

Note by Sir John Richardson.

Sir John Richardson, who made several journeys up and down the Saskatchewan in the early part of the present century, states: "We obtained specimens exactly similar to those (limestone) in Lake Winnipeg from Manito-baw Lake, and were informed that it abounds much further to the southward."§

He also describes the Scapulæ of *Mastodon giganteus* obtained through the exertions of Dr. Rae "from Swan River (properly Swan River District) near the western side of the basin of Lake Winnipeg."

T. Simpson, 1836.

On the first of December, 1836, Thomas Simpson left Fort Garry on his famous journey to the north and crossing Lake Manitoba on the ice reached Manitoba House on the 6th. Thence he coasted the west shore of the lake to Meadow Portage, and travelled on the ice of Lake Winnipegosis to Duck Bay. At Duck Bay he struck inland by a winter trail to Swan Lake, from which he ascended the Swan River

*A Brief Narrative of the Journeys of David Thompson in North-western America by J. B. Tyrrell. Proc. Can. Inst., Vol. VI., pp. 135–160.

†Alexander Henry's Manuscript in the Parliamentary Library in Ottawa.

‡A Journal of Voyages and Travels in the Interior of North America, by Daniel Williams Harmon. Andover, 1820.

§Franklin Journey to Polar Sea. London, 4to. 1823, p. 506. Richardson's Appendix.

Zoology of the Voyage of H.M.S. "Herald." London, 4to. 1854, pp. 101-102 and 141–42.

valley to Fort Pelly and going by way of Fort Carlton hurried on to the Mackenzie River.

On his return journey he reached Fort Pelly on the 22nd of January, 1840, and then turned southward by the trail on the west side of the Assiniboine River.

He gives short descriptions of lakes Manitoba and Winnipegosis and mentions the manufacture of salt by "freemen" for sale to the Hudson's Bay Company.*

J. Palliser, 1857.

In October, 1857, Capt. J. Palliser, returning from Fort Carlton, travelled down the trail on the west side of the Assiniboine from Pelly to Ellice, and has left a short general description of that portion of the country.†

S. J. Dawson, 1858.

In May, 1858, Mr. S. J. Dawson left Fort Garry and crossed over to "Manitouba" Lake, on which he embarked, and thence travelled in canoes to the north-west end of "Winnipegon" Lake, crossed the Mossy Portage to Bourbon (Cedar) Lake and descended the Saskatchewan to Grand Rapids. On his return to Mossy Portage he divided the party, giving Mr. Wells, his assistant, charge of one section, while with the other section of the party he ascended the Swan River in canoes to the Pelly Crossing and descended the Assiniboine from Fort Pelly to its mouth.

He gives a description of the character of the shores of lakes Manitoba and Winnipegosis and mentions the occurrence of limestone towards the north end of the latter lake. He also notes the occurrence of mineral springs near the mouth of Swan River, from some of which salt was being made. Swan Lake, and the valley of Swan River are then glowingly described, the latter being correctly stated to be one of the most beautiful tracts of country that he had passed through. A good general description is then given of the valley of the Assiniboine from the Elbow at Fort Pelly to its mouth. He mentions having found float coal on Swan River, and that the Indians report it on Rolling River, Thunder Mountain and Red Deer River.

A. W. Wells, 1858.

Mr. A. W. Wells, who took charge of the second division of the party, measured the length and height of Mossy Portage, giving its length at four miles and eighteen chains and height of Lake Winnipegosis as four feet above Cedar Lake. From Mossy Portage he travelled southward along the west side of Lake Winnipegosis to Mossy River, which he ascended to Lake Dauphin. From Mossy

*Narrative of the Discoveries on the North Coast of America by Thomas Simpson, London. 8vo. 1843, pp. 31-36.

†The Journals, Detailed Reports and Observations relative to the Exploration, &c., by Capt. J. Palliser. London, folio, 1863, pp. 59-60

River he travelled by the north end of Lake Manitoba, whence he descended by St. Martin's River to Lake Winnipeg. He mentions the salt springs on Lake Winnipegosis and the occurrence of limestone on Mossy River and Snake Island, the former poor and the latter rich in included organic remains.

After reaching Fort Garry, Mr. Dawson and his assistant proceeded to examine the country between Red River and Lake Superior.

Attached to Mr. Dawson's report is a letter from Mr. E. Billings, dated 21st February, 1859, inclosing others from Messrs. Meek and Hayden, J. W. Dawson and J. R. Jones. This letter states that the fossils collected show the existence of Cretaceous rocks in the Canadian North-west, a fact which had been previously recognized by Dr. Hector in 1857, but which had not yet been made public. The first inclosure identifies the Cretaceous fossils, the second inclosure fossil woods and lignite, and the third a Palæozoic Ostracod.*

H. Y. Hind, 1858.

On the 13th of September, 1858, Professor H. Y. Hind accompanied by Mr. John Fleming as assistant entered Manitoba Lake from St. Martin's River. Crossing this lake, they ascended Waterhen River to Lake Winnipegosis and sailed to the mouth of Mossy River, calling at Snake Island and the salt works on the way. Mossy River was ascended with some difficulty and camp was pitched on the south shore of Dauphin Lake, at what was considered the nearest point to Riding Mountain. From the 9th to the 12th of October was spent in ascending the escarpment of Riding Mountain and descending again to the lake, whence Mr. Hind crossed by land on horseback to Manitoba House, while Mr. Fleming went round by the Waterhen River with the boat. While waiting at Manitoba House for Mr. Fleming, Mr. Hind examined the Devonian rocks on Manitoba Island.

From Manitoba House they crossed the lake to Oak Point, whence they returned to Fort Garry.

The report of this expedition contains records of many interesting geological observations, among which is the first notice of the occurence of Devonian strata east of the Manitoba escarpment.

John Fleming, 1858.

In August of the same year, Mr. Fleming had descended the Saskatchewan from Fort à la Corne to its mouth, on which trip he estimated the fall of the Grand Rapids at forty-three and a half feet.

*Papers relative to the exploration of the country between Lake Superior and the Red River Settlement, London, Govt., 1859. This report is accompanied by four maps, two of which are entitled "Sketch of Region explored between Red River and the Great Saskatchewan" and "Thompson's map showing the different tracks of the Saskatchewan and Assiniboine Exploring Expedition" in charge of Prof. H. Y. Hind.

Also the same report in Appendix No. 36 to the Seventeenth Volume of the Journals of the Legislative Assembly of the Province of Canada. Toronto, 4to. 1859.

This has been found to be an under-estimate, as the actual fall is seventy-one feet.

In July of the same year Mr. Dickinson, one of Mr. Hind's assistants, travelled from Ellice to Pelly, up the west side of the Assiniboine, and thence turning southward he followed the west side of the Little Saskatchewan, which he explored for part of its course, afterwards returning to Ellice. He makes no mention of the geology.*

Lord Southesk, 1859.

On the 9th December, 1859, Lord Southesk arrived at Fort Pelly on his return from a hunting trip to the Rocky Mountains. On the 28th of the same month he left this post in a carriole drawn by three dogs and descended the Swan River valley to Swan Lake, which he crossed on the ice, and travelled on the winter trail through the spruce forest to Duck Bay where the Hudson's Bay Company had just established a trading post. From Duck Bay he rode across the ice of Lake Winnipegosis to Meadow Portage and thence down Lake Manitoba to the mission at St. Laurent. He mentions the occurrence of salt springs, and indicates the possibility of springs in the bottom of the lake, as there are places where the ice is always dangerous.†

H. B. Smith, 1873.

In 1873, Henry B. Smith, C.E., made some explorations in this district in connection with the surveys of the Canadian Pacific Railway, with a view to determine the extent and nature of its navgable water-stretches, and the character of the barriers that separate them from each other.

"The Saskatchewan River between Cedar Lake and Winnipeg" is first briefly discussed, then "Mossy Portage between Cedar Lake and Winnipegosis" is described, and a plan and section of it are given. The two lakes are stated to have the same elevation, and the highest point of the portage is a quarter of a mile from Lake Winnipegosis, with an elevation of 93·14 feet above Cedar Lake. The approaches to the portage are also described. "Waterhen River, between Lakes Winnipegosis and Manitoba," is next considered, and a plan and section of the river are given. "Meadow Portage, between lakes Winnipegosis and Manitoba," is stated to have a length of one mile and three-quarters (given in the plan as 1 mile 57 chains 20 links), and the difference in level of the two lakes is stated as 18·73 feet, the greatest elevation being ten feet above Lake Winnipegosis. The approaches to this portage are also described. "Partridge Crop and

*Reports of Progress, together with a Preliminary and General Report on the Assiniboine and Saskatchewan Exploring Expedition by Henry Youle Hind, M.A. Appendix No. 36 to the Journals of the Legislative Assembly. Toronto. 4to. 1859.

†Saskatchewan and the Rocky Mountains, by Earl of Southesk. Edinburgh. 8vo. 1875.

Dauphin (St. Martin's) rivers, between lakes Manitoba and Winnipeg" are next discussed, and their depth and breadth given in several places.*

In the summer of 1874, Dr. R. Bell, of the Canadian Geological Survey, travelled with carts from Fort Garry to Fort Pelly, going by way of Fort Ellice and the trail on the west side of the Assiniboine River. From Fort Pelly he examined the eastern trail southward to Big Boggy Creek, and the valleys of Big Boggy Creek and Shell River in parts of their course. Returning to Fort Pelly he rode down the Swan River valley on the trail north of the river to a point four miles above the mouth of Rolling River where he found the pyritiferous sandstone that has since been determined as representing a horizon about the top of the Dakota formation. Returning again to Fort Pelly he embarked in a skiff on the Assiniboine and followed its windings as far as Fort Ellice. From Fort Ellice he crossed to the south end of Lake Manitoba and proceeded up the west side of the lake to the Narrows, and thence across to Fairford at the discharge of the lake. From Fairford he descended the Fairford and St. Martin's (Little Saskatchewan) rivers to Lake Winnipeg. R. Bell, 1874.

Throughout this distance exposures of Cretaceous shales were noted on the banks of the Assiniboine, and Devonian limestones at two places on Lake Manitoba, but no fossils were collected in either case.†

Dr. J. W. Spencer, acting as Dr. Bell's assistant in 1874, examined the lower portion of Shell River, and descended Swan River in a small boat from the Pelly crossing to its mouth, branching off in one place to climb to the top of Thunder Hill. From the mouth of Swan River he crossed Swan, Winnipegosis and Manitoba lakes to Oak Point, whence he returned to Fort Garry. J. W. Spencer, 1874.

In the Swan River valley, and on the face of Thunder Hill and Porcupine Mountain Cretaceous beds were observed, and specimens collected from the former locality were determined by Dr. George M. Dawson, on the evidence of the contained fossil foraminifera, to be of Niobrara age. Devonian rocks were also noticed on the shores of the various lakes passed through, and some typical fossils were collected from them or from loose masses of rock in their vicinity.‡

*Memorandum on the portages and streams between Lakes Winnipeg, Manitoba, Winnipegosis and the River Saskatchewan at Cedar Lake. From reports of surveys made by Henry L. Smith, C.E., in 1873. Appendix O. C.P.R. Report, 1874, pp. 259-262, with maps and profiles on sheet No. 11, Ottawa, 1874.

†Report on the country west of Lakes Manitoba and Winnipegosis by Robert Bell, C.E., F.G.S. Geol. Survey of Canada, Rept. of Prog., 1874-75, pp. 24-56. Montreal, 1876.

‡Report on the country between the Upper Assiniboine River and Lakes Winnipegosis and Manitoba by Joseph William Spencer, B. Ap. Sc. Geol. Survey of Canada, Rept. of Prog., 1874-75, pp. 57-70. Montreal, 1876.

G. C. Cunningham, 1874.

In the summer and autumn of 1874, Granville C. Cunningham located the old Canadian Pacific Railway line from Mossy River to the crossing of Snake Creek, around the north-east angle of the Duck Mountain. He gives a short, but clear description of the character of the country passed through, mentioning the occurrence of gravel ridges in several places.*

Swan River bore, 1875.

In the summer of 1875 Mr. Fairbank, of Petrolea, under contract with the Geological Survey of Canada, sank a bore-hole in the valley of Swan River close to the old Mounted Police barracks. A depth of 501 feet was reached, and the rocks throughout were found to be of Cretaceous age.†

J. Macoun 1881.

In June, 1881, Prof. John Macoun, now of the Geological Survey Department, sailed northward across Lake Manitoba, ascended Waterhen River, and traversed the whole length of Lake Winnipegosis, reaching Shoal River House on the seventh of July. Here he built a boat with which he ascended Red Deer River to the forks, turned southward into Etoimami River and ascended it and Little Swan River to a marsh in the bottom of a valley. Making his way through this marsh he came on Swan River which he descended to the Mounted Police barracks at the mouth of Snake Creek, which he reached fifty-one days after leaving the mouth of Red Deer River. From here he made short excursions into the adjoining hills to the north-east and south-east. From Fort Pelly he descended the Assiniboine to Fort Ellice, whence he returned east.

The year was one of very high water, and much of the country immediately adjoining the lakes was flooded. He mentions the occurrence of limestone on lakes Manitoba and Winnipegosis, and especially notices the great fertility of the soil.

The salt springs are discussed at some length and a list is given of a number of places where they are to be found. On Red Deer River he records the occurrence of outcrops of fossiliferous limestone below Red Deer Lake and sandstone above it. The consideration of the extent and character of the forests in this valley is not the least interesting part of his report.‡

T. Guerin, 1881.

In the same summer, Thomas Guerin, C.E., was sent by the Department of Public Works to find out the cause of the abnormal rise of

*Report on an Exploratory Survey between Lake Winnipegosis and Livingstone during the summer and autumn of 1874 by Granville C. Cunningham. Appendix L. C. P. R., Rep., 1877, pp. 185-188. Ottawa, 1877.

†Boring made on Swan River, near Fort Pelly, in 1875. Alfred R. C. Selwyn. Geol. Survey of Canada, Rept. of Prog., 1875-76, pp. 292-3. Montreal, 1877.

‡Report on Exploration by Prof. John Macoun, M.A., F.L.S. Ann. Rep., Dept. of Interior, 1881, Pt. I., pp. 67-88. Ottawa, 1882.

the water in Manitoba and St. Martin's lakes during that and the preceding year, and if possible to devise some means of lowering the water and keeping it at its normal level. He found that a band of limestone stretched across the head of the Fairford River. The White Mud, Waterhen, Fairford and St. Martin's (Little Saskatchewan) rivers were measured and cross sections were made, and the total amount of water discharged by each of them at that time was calculated.*

D. L. surveys.

Several surveys have been made by the Dominion Lands Branch of the Department of Interior, among which the most important are the following:

In the winter of 1878, Wm. Wagner made a transit and chain traverse of Lake Manitoba.

In the winter of 1880, Wm. Pearce, D.L.S., ran the meridian township outline between ranges 18 and 19 in the old system of survey on the ice across Winnipegosis and Cedar lakes.

In the summer of 1887, J. I. Dufresne, D.L.S., made a survey with transit and micrometer of the south and west shores of Lake Winnipegosis, and of Shoal River and Swan Lake. In his report he gives generally the character of any timber seen, and the positions of a number of outcrops of limestone.†

Previous reports on the work of this exploration.

As a result of the present exploration, the following reports and papers have already been published:

Harrington, B. J.—On the so-called Amber of Cedar Lake, North Saskatchewan, Canada. Am. Jour. Sci., Vol. 42 (Oct., 1891), pp. 332–5.

Jones, Prof. T. Rupert.—On some Ostracoda from the Cambro-Silurian, Silurian and Devonian rocks. Geol. Sur. Can., Contribs. to Can. Micro-Pal., Part III., with 3 plates. Montreal, 1891.

Nicholson, H. Alleyne.—On some new or imperfectly known species of Stromatoporoids. Ann. & Mag. N. Hist., ser. 6, Vol. VII. (Apl., 1891,) pp. 309–328, with 2 plates.

Dawson, Sir William, and Prof. D. P. Penhallow.—On the Pleistocene Flora of Canada. Bull. Geol. Soc. Am., Vol. I. (1890) pp. 311–334.

Rüst, Dr. D.—Radiolaria from the Pierre Formation of Northwestern Manitoba. Geol. Sur. Can., Contribs. to Can. Micro-Pal., Part IV., with 3 plates. Ottawa, 1892.

*General Report of the Minister of Public Works from 30th June, 1867, to 1st July, 1882, pp. 535–536. Ottawa, 1883.

†Exploratory Survey of Lake Winnipegosis and of Swan and Red Deer (Overflowing) Rivers. Ann. Rep. Dept. Interior, 1887, Pt. II., pp. 71–74. Ottawa, 1888.

Penhallow, D. P.—A new species of Larix from the Interglacial of Manitoba. Am. Geol., Vol. 9 (June, 1892) pp. 368–371.

Scudder, S. H.—Canadian Fossil Insects. Geol. Sur. Can., Contribs. to Can. Pal., Vol. II., pp. 30–31, with plate. Ottawa, 1892.

Whiteaves, J. F.—On some Cretaceous fossils from British Columbia, the North-west Territory and Manitoba. Geol. Sur. Can., Contribs. to Can. Pal., Vol. I., Part II., pp. 185–196, with plate. Montreal, 1889.

Whiteaves, J. F.—Descriptions of some new or previously unrecorded species of fossils from the Devonian rocks of Manitoba. Trans. Roy. Soc. Can., Vol. VIII., Sec. IV., pp. 93–110, with 7 plates. Montreal, 1891.

Whiteaves, J. F.—Descriptions of four new species of fossils from the Silurian rocks of the south-eastern portion of the District of Saskatchewan. Can. Rec. Sci., Vol. IV., Apl., 1891, pp. 293–303, with plate.

Whiteaves, J. F.—The Fossils of the Devonian rocks of the islands, shores or immediate vicinity of Lakes Manitoba and Winnipegosis. Geol. Sur. Can., Contribs. to Can. Pal., Vol. I., Part IV., with 15 plates. Ottawa, 1892.

Hoffmann, G. Christian.—Chemical Contributions to the Geology of Canada. Geol. Sur. Can., Ann. Rep., N.S., Vol. IV., 1888–9. Part R., 1890, p. 6 R.

Hoffmann, G. Christian.—Chemical Contributions to the Geology of Canada. Geol. Sur. Can., Ann. Rep., N.S., Vol. V., 1889–90–91. Part R., 1892, pp. 26–37.

Tyrrell, J. B.—Short account of the work done in the Duck and Riding Mountains in 1887. Ann. Rep., Dept. of Int., 1887. Part III., pp. 11–14. Ottawa, 1888.

Tyrrell, J. B.—Short account of the examinations of Lakes Manitoba and St. Martin. Ann. Rep., Dept. of Int., 1888. Part III., pp. 12–14. Ottawa, 1889.

Tyrrell, J. B.—Short account of the examinations of Lake Winnipegosis and vicinity. Ann. Rep., Dept. of Int., 1889. Part III., pp. 12–18. Ottawa, 1890.

Tyrrell, J. B.—Short account of the Assiniboine and Lower Saskatchewan Rivers. Sum. Rep., Geol. Sur. Dept., 1890, pp. 19–26. Ottawa, 1891.

Tyrrell, J. B.—Notes to accompany a preliminary map of Duck and Riding Mountains in North-western Manitoba. Geol. Sur. Can., Ann. Rep. N.S., Vol. III., 1887–8. Pt. E. Montreal, 1888.

Tyrrell, J. B.—Gypsum Deposits in Northern Manitoba. Can. Rec. Sci. (Apl., 1889), Vol. III., pp. 353–360.

Tyrrell, J. B.—Post-Tertiary Deposits of Manitoba and the adjoining Territories of North-western Canada. Bull. Geol. Soc. Am., Vol. I., Apl., 1890, pp. 395–410.

Tyrrell, J. B.—Foraminifera and Radiolaria from the Cretaceous of Manitoba. Trans. Roy. Soc. Can., Vol. VIII., 1890, Sec. IV., pp. 111–115.

Tyrrell, J. B.—The Cretaceous of Manitoba. Am. Jour. Sci., Vol. XL., 3rd Ser., Sept., 1890, pp. 227–232.

Tyrrell, J. B.—Pleistocene of the Winnipeg Basin. Am. Geol., Vol. VII., July, 1891, pp. 19-28.

Tyrrell, J. B.—Three deep Wells in Manitoba. Trans. Roy. Soc Can., Vol. IX., 1891, Sec. IV., pp. 91-104.

PHYSICAL GEOGRAPHY.

GENERAL FEATURES.

Position and area.

The map accompanying this report covers an area lying between latitudes 50° 47′ and 53° 19′ 30″ north, and longitudes 98° 40′ and 101° 56′ 30″ west, measured along its southern margin, and thus incloses about 25,300 square miles. Of this area 15,600 square miles are within the province of Manitoba; 5,600 square miles are in the district of Saskatchewan, and 1,500 are within the district of Assiniboia. About 4,000 square miles in the north-eastern and north-western portions of this region are as yet unexplored, so that the total area mapped and described in the following report slightly exceeds 21,000 square miles. At the commencement of the exploration it was intended to confine the work to the country lying south of the Saskatchewan River, and the main portion of the report is written with this impression in view; but on account of the uncertainty in which the exact taxonomic position of the rocks on the east side of Lake Winnipegosis was then left it was found necessary to extend the exploration to Cedar Lake and the lower stretches of the Saskatchewan, east of that lake, and a brief description of the geology of this water-stretch which has been so often travelled, but was yet so imperfectly known, has been incorporated.

Lacustral plain.

The general character of the surface is remarkably simple and is well shown by the contour lines on the accompanying map. The eastern two-thirds of the district is a lightly undulating plain sloping gently to the bottom of Lake Winnipeg. The depressions in the surface of this great plain are filled with shallow bodies of water with more or less irregular confines, and their waters are more or less rily from the presence of suspended clayey matter degraded by the waves from the surrounding shores of boulder clay or alluvium. These lakes are connected by short rapid streams, generally navigable for canoes, and with the exception of Swan and Red Deer lakes are chiefly fed by streams running from the face of the Manitoba escarpment.

Manitoba escarpment.

This escarpment is the most prominent geographical feature of the whole region. It rises from the lacustral plain, at first by a very gentle incline which gradually becomes steeper, till in the more typical places it reaches an almost abrupt declivity of several hundred feet. From the top of this escarpment, if a favourable place be chosen, not too much obstructed by forest growth, a far-reaching view may be had of

the vast plain stretching apparently from beneath the feet of the observer to the almost level horizon.

West of the brow of the escarpment lies the rugged table land of the Riding, Duck and Porcupine Mountains, often still rising for several hundred feet to extreme heights of more than two thousand seven hundred feet above the sea, or two thousand feet above the surface of Lake Winnipeg, and then declining gradually towards the south-west. This table land is generally densely wooded and travel over it is necessarily slow and difficult, but wherever examined, its summit near the edge of the escarpment was found to consist of irregular boulder-covered hills, wooded with small pine and spruce, while farther west extensive level tracts were found clothed with large spruce, and still further west it is trenched by deep valleys carrying small tributary streams down to the Assiniboine River. Table land.

Both to the south and north of Porcupine Mountain the table land is cut through by large and very ancient valleys at present drained by Swan and Red Deer rivers, valleys that have evidently been formed by streams that flowed eastward into the great river that ran between the face of the escarpment and the Archæan plain east of Lake Winnipeg. Valleys.

In the south-westerly part of the district the slope is towards the valley of the Assiniboine, and the country gradually changes from a thick forest, through partly wooded country, to open prairie.

The drainage of the whole surface finds its way into Lake Winnipeg, and thence by the Nelson River to Hudson Bay; but it discharges into Lake Winnipeg by three distinct and widely separated channels, viz., the Saskatchewan, the St. Martin's or Little Saskatchewan, and the Red rivers.

Across the north-east corner of this district the Saskatchewan carries the snow-waters of the Rocky Mountains to Lake Winnipeg, but no tributaries of any size join it here.

St. Martin's River empties into Sturgeon Bay on the south-west side of Lake Winnipeg, one hundred miles south-east of the mouth of the Saskatchewan, and carries with it the drainage of the greater part of this area. It is the channel of overflow of lakes St. Martin and Manitoba, and the chief tributary of this latter lake is the Waterhen River flowing from Waterhen Lake and Lake Winnipegosis. This lake is the collecting basin for the water draining the eastern face of the Manitoba escarpment, and those portions of the plains tributary to the Swan and Red Deer rivers. St. Martin's River.

The south-western corner of the district is drained by the Assiniboine which enters it from the west at Fort Pelly. It immediately Assiniboine River.

turns sharply to the S.S.E., and flowing for nearly eighty miles, leaves it just east of the western boundary of Manitoba. In this distance it receives the White Sand and other tributaries from the west, and the Little Boggy, Big Boggy and Shell rivers from the east, carrying off the drainage of the greater portion of the summit plateau of the Duck Mountain.

Adaptabilities of the country.

The adaptabilities of the country are very varied, and will be discussed at greater length in succeeding pages of the report, when the different areas are considered in detail; but it may be stated that the slope extending from the foot of the more abrupt escarpment to the western shores of Lakes Manitoba and Winnipegosis and the valleys of Swan and Red Deer rivers is eminently fitted for mixed farming. It is well supplied with water, though much of it needs to be drained. It is a for the most part underlaid by a clay soil derived from the degradation of the soft limestones and shales of the Cretaceous beds to the west, and is greatly enriched by the abundance of phosphatic material supplied by large deposits of fish remains included in these beds. In the immediate vicinity of the large lakes and on their eastern side the amount of alluvium is comparatively very small, but doubtless much of the calcareous boulder-clay with which the country is covered would be found to yield profitable harvests of the more hardy roots and cereals.

The country west of the escarpment in this part of Manitoba will probably never be a very successful wheat-raising district, but the hardier cereals can be grown with the assurance of an abundant crop, and the country is eminently suited to the raising of cattle for dairying purposes, for rich nutritious grass covers the surface everywhere except in the dense forest.

Natural products.

Much fine timber is growing on the remoter parts of the mountains, but a very large amount of spruce has during late years been destroyed by forest fires.

The manufacture of salt could readily be carried on, especially in the vicinity of Dawson Bay, where the natural brine springs are much more copious than elsewhere.

The lakes abound in food-fish, and with careful fishing can be made to yield a large and constant supply. Much large game is still to be found. Moose are plentiful throughout the wooded tracts everywhere; caribou are especially numerous on the east side of Lake Winnipegosis, and a few elk are still to be found between Riding Mountain and lakes Manitoba and Winnipegosis. The black bear wanders among the streams and by the lakes. Other fur-bearing

animals common to Manitoba and the North-west are taken by the hunters in greater or less abundance.

Climate.

The climate is remarkably clear and beautiful. In June and July, the prevalent winds are from the south, ushering in warm days accompanied by frequent heavy showers of rain, while later in the year westerly and north-westerly winds prevail accompanied by drier weather.

Frost.

Frost generally occurs in the early part of June and the latter part of August on the high lands west of the Manitoba escarpment, but the country to the east of this line enjoys a greater interval between the frost periods.

Table of temperature and rainfall.

The following table has been kindly prepared by Prof. C. Carpmael, Director of the Canadian Meteorological Service, and shows the temperature and rainfall better and clearer than any extended discussion would do. It is prepared for Minnedosa which is situated in a wide valley on the edge of the escarpment, on the eastern side of range 18, and thirty-five miles south of the limit of the accompanying map, and Russell at the terminus of the Manitoba and North-western Railway. The observing station at Minnedosa has an elevation of 1,689 feet above the sea, and that at Russell an elevation of about 1,830 feet. This latter is the only place in the district at which meteorological observations are at present taken, but the record is doubtless essentially correct for the country north at least to the Swan River valley, while the daily range in summer on the lacustral plain is certainly less than on the higher table land, and there is thus less probability of erratic frost.

STATISTICS of Temperature and Precipitation at Minnedosa, Manitoba, Latitude North 51° 10′, Longitude West, 99° 48′, height above sea, 1,665 feet.

By PROF. C. CARPMAEL.

AVERAGE MONTHLY TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1881	.....	.....	.....	.....	.....	.....	65·25	61·35	47·24	30·22	12·26	9·78	.....
1882	— 2·54	6·67	8·63	28·62	47·55	57·19	60·93	64·69	53·66	38·19	18·29	2·80	32·06
1883	—15·38	7·01	5·86	30·96	44·40	57·71	58·19	57·85	47·93	33·59	12·18	—0·42	28·32
1884	— 7·63	—10·76	10·52	31·97	50·83	62·07	56·81	58·05	46·52	36·34	18·23	—4 80	29·01
1885	—12·20	— 6·87	11·77	34·09	46·70	55·68	60·48	54·08	49·02	34·97	24·94	10 16	30 24
1886	—14·43	1·23	13·75	38·98	52·09	60·70	66·76	59·50	44·70	41·07	16·12	—1·15	31·61
1887	—13·45	— 7·96	11·75	34·16	53·13	60·98	62·17	56·61	50·55	31·13	17·12	0·31	29·71
1888	— 11·55	1·18	3·94	28·98	44 28	58·97	62·37	55·89	47·08	35·08	18·30	12·28	29·54
1889	4·92	— 4·06	24·82	40·47	48·76	62·50	63·36	62·18	45·75	35·08	19·78	7·59	34·26
1890	—11·52	— 8·64	7·70	35·82	42·10	65·18	65·36	57·41	45·06	38·26	.....	.....	.....
Average	— 9·31	— 2·73	10·97	33·78	47·77	60·11	62·17	58·76	47·75	35·39	17·47	4·06	30·52

AVERAGE MONTHLY MAXIMUM.

1881	.....	.....	28·9	42·2	65·6	68·2	76·9	71·6	56·9	38·7	20·3	19·9	.....
1882	7·3	18·0	19·6	38·6	59·9	69·2	72·3	76·4	66·3	47·2	26·1	13·3	.....
1883	— 4·3	5·3	17·0	42·4	57·8	69·8	70·8	69·4	61·7	41·0	21·6	9·4	.....
1884	3·1	— 1·0	20·8	41·8	65 8	74·2	74·8	71·8	58·6	47·2	25·9	3·5	.....
1885	— 3·2	— 0·4	22·6	45·1	59·6	68·2	72·1	67·7	64·6	46·1	31·8	21·0	.....
1886	— 4·8	13·8	26·0	51·4	65·2	73·9	79·6	75·8	59·7	54·2	27·8	8·1	.....
1887	— 1·1	3·8	24·5	47·1	67·0	71·9	74·0	70·1	65·8	43·9	28·7	10·0	.....
1888	— 2·5	9·8	15·2	39·8	57·4	69 4	74·7	72·4	66·4	48·9	31·9	24·8	.....
1889	19·0	12·2	40·4	56·6	64·1	77·5	77·7	79·8	62·7	52·8	35·2	20·3	.....
1890	2·2	6·1	22·5	49·9	55·2	77·2	78·2	71·3	62·3	50·2	.....	.....	.....
Average	1·7	7·5	23·7	45·5	61·8	71·9	75·1	72·6	62·5	47 0	27·7	14·5	.....

1888	— 2·5	9·8	15·2	39·8	57·4	69·4	74·7	72·4	66·4	48·9	31·9	24·8	.....
1889	19·0	12·2	40·4	56·6	64·1	77·5	77·7	79·8	62·7	52·8	35·2	20·3	.....
1890	2·2	6·1	22·5	49·9	55·2	77·2	78·2	71·3	62·3	50·2	.....	.....	.....
Average	1·7	7·5	23·7	45·5	61·8	71·9	75·1	72·6	62·5	47·0	27·7	14·5	.....

AVERAGE MONTHLY MINIMUM AND MEAN DAILY RANGE.

1881	.....	.....	.....	.....	.....	.....	53·6	51·1	37·6	21·7	4·2	0·4	.....
1882	— 12·3	— 4·7	— 2·4	18·7	35·2	45·2	49·5	52·9	41·0	29·2	10·5	— 7·7	.....
1883	—26·6	—16·0	— 7·7	21·1	30·1	44·1	45·1	44·8	35·2	24·6	0·1	12·7	.....
1884	—21·5	25·0	— 1·2	21·0	34·8	49·5	44·0	45·6	36·0	25·4	6·2	2·0	.....
1885	— 25·2	—20·6	— 1·3	22·1	33·2	41·6	48·2	41·3	33·8	23·7	16·4	— 5·1	.....
1886	— 26·9	—13·6	— 0·2	26·5	35·7	44·0	51·1	44·3	31·2	28·8	3·2	13·2	.....
1887	—29·4	21·3	— 2·0	20·9	39·1	47·4	47·8	42·5	36·5	18·5	5·0	—10·2	.....
1888	—23·7	—13·5	— 8·8	18·5	28·7	45·5	49·0	42·2	36·2	28·8	11·1	3·4	.....
1889	— 6·0	—15·2	15·3	28·3	34·4	44·8	48·9	46·9	35·9	26·0	10·5	— 3·7	.....
1890	—20·7	—18·7	— 3·9	24·9	29·1	50·5	50·0	43·6	34·7	31·8	.....	.....	.....
Average	—21·4	—16·3	— 1·4	22·6	33·4	45·8	48·7	45·5	35·8	25·9	7·5	— 7·6	.....
Mean Daily Range	23·1	23·8	25·1	22·9	28·4	26·1	26·4	27·1	26·7	21·1	20·2	22·1	24·42

HIGHEST TEMPERATURE REGISTERED.

1881	35·8	27·4	40·8	76·0	78·0	82·8	86·5	85·6	74·5	59·7	45·6	36·4	86·5
1882	28·1	38·5	42·8	48·6	78·7	81·8	84·8	86·6	82·0	63·7	41·0	31·7	86·6
1883	28·5	37·9	36·6	68·0	72·3	91·8	81·8	78·8	67·8	56·2	44·8	36·3	91·8
1884	19·9	28·7	43·8	64·2	82·0	86·0	77·3	85·0	69·6	72·8	49·7	41·6	86·0
1885	27·5	41·8	40·2	63·3	76·8	83·3	88·2	82·0	82·3	69·8	44·8	37·9	88·2
1886	19·9	44·6	47·6	76·3	83·8	88·0	92·0	102·6	82·8	82·4	63·2	38·8	102·6
1887	21·7	21·7	47·6	79·8	90·0	86·3	89·8	82·8	83·8	67·2	66·5	33·6	90·0
1888	35·9	38·4	36·9	66·1	73·2	93·8	84·3	84·3	82·8	75·8	47·3	37·9	93·8
1889	35·4	39·8	66·2	79·8	81·3	98·8	88·8	92·7	93·3	81·1	57·7	34·9	98·8
1890	28·4	35·4	35·7	69·8	68·8	87·3	94·3	90·4	87·1	82·8	56·2	.....	94·3
Average	28·1	35·4	43·8	69·2	78·5	88·2	86·8	87·1	81·6	71·2	51·7	36·6	92·1

Statistics of Temperature and Precipitation at Minnedosa, Manitoba, &c.—*Continued.*

LOWEST TEMPERATURE REGISTERED.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1881	.....	.....	.....	.....	.....	.....	41·2	40·8	24·9	4·3	— 26·9	— 29·2	.....
1882	— 39·2	— 38·5	— 26·0	— 10·2	20·6	33·4	38·4	33·2	22·6	21·2	— 6·2	— 33·2	— 39·2
1883	— 50·2	— 43·2	— 30·4	0·0	16·8	29·2	37·7	31·2	5·8	10·9	— 28·2	— 43·2	— 50·2
1884	— 48·8	— 40·8	— 35·2	8·9	18·3	35·0	32·7	31·0	23·6	0·6	— 31·4	— 46·7	— 48·8
1885	— 43·4	— 48·0	— 29·2	— 7·2	12·4	24·4	37·3	24·5	21·6	11·9	1·3	— 25·2	— 48·0
1886	— 52·2	— 48·7	— 24·7	— 14·7	14·3	26·0	37·0	24·5	11·7	11·9	— 23·6	— 39·5	— 52·2
1887	— 43·5	— 43·0	— 37·0	— 4·2	24·0	27·8	35·8	27·6	14·9	— 11·4	— 37·0	— 43·0	— 43·5
1888	— 44·5	— 50·6	— 28·8	— 4·2	14·9	22·5	38·5	38·5	15·4	14·9	— 11·4	— 14·0	— 50·6
1889	— 34·3	— 52·2	— 12·4	11·4	20·0	33·5	36·5	32·0	19·0	1·8	— 7·8	— 26·1	— 52·2
1890	— 39·0	— 46·0	— 33·3	— 2·9	14·9	36·8	40·0	27·5	22·0	20·0	— 1·2	.....	— 46·0
Average	— 43·9	— 45·7	— 28·6	— 2·6	17·4	29·8	37·5	31·1	18·1	8·6	— 17·2	— 33·3	— 47·9

RAINFALL IN INCHES.

	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1881	0·00	0·00	0·00	0·14	4·25	7·85	3·03	1·14	4·64	1·14	0·00	0·00	22·19
1882	·00	..	·00	1·89	1·11	2·47	3·24	1·45	0·80	4·85	0·00	·00	15·81
1883	·00	·00	·00	0·14	0·88	2·03	1·38	1·63	0·30	1·82	0·00	·00	8·18
1884	·00	·00	·00	0·26	0·27	3·30	3·17	3·76	2·94	1·15	0·03	·00	14·88
1885	·00	R.	·00	1·05	2·44	3·01	2·26	1·90	0·46	0·11	0·10	·00	11·33
1886	·00	·00	·00	1·16	1·63	1·25	1·88	0·76	0·84	1·04	0·00	R.	8·56
1887	·00	·00	·00	0·10	2·24	6·95	1·89	1·53	1·15	0·30	0·02	·00	14·18
1888	·00	·00	·00	0·01	0·64	3·68	4·59	1·27	0·27	0·59	0·00	·00	11·05
1889	·00	·00	0·14	0·52	1·74	0·94	1·50	1·80	0·98	0·22	0·40	·00	8·24
1890	·00	·00	·00	0·47	1·56	4·72	2·72	3·81	1·90	1·41	.....	.....	16·59
Average	·00	R.	0·01	0·57	1·68	3·62	2·57	1·90	1·43	1·26	0·06	R.	13·10

1888	·00	·00	0·14	0·52	1·74	0·94	1·50	1·80	0·98	0·22	0·40	·00	8·24
1889	·00	·00	·00	0·47	1·56	4·72	2·72	3·81	1·90	1·41	.....	.....	16·59
1890	·00	·00	0·01	0·57	1·68	3·62	2·57	1·90	1·43	1·26	0·06	R.	13·10
Average													

SNOW, IN INCHES, AND TOTAL PRECIPITATION.

1881	1·5	27·0	8·0	8·0	0	0	0	0	0	10·0	14·6	2·0	71·1
1882	14·5	9·0	12·0	4·5	*	0	0	0	0	4·0	14·1	6·0	64·1
1883	4·0	5·7	8·5	11·5	*	0	0	0	*	*	4·5	18·5	52·7
1884	6·8	5·7	10·0	9·9	0	0	0	0	0	6·2	7·6	6·2	52·4
1885	2·8	5·4	9·6	8·8	1·5	0	0	0	0	5·0	1·3	10·8	45·2
1886	5·1	5·0	4·0	9·4	*	0	0	0	0·5	1·1	4·1	1·4	30·6
1887	4·9	5·0	2·1	8·3	1·0	0·5	0	0	0	1·3	8·5	8·2	39·8
1888	4·8	2·5	10·0	10·1	0·7	0	0	0	0	8·4	4·0	4·5	45·0
1889	10·4	5·1	0·9	1·7	*	0	0	0	*	0·6	4·9	12·3	35·9
1890	3·3	23·0	2·3	1·4	3·3	0	0	0	*	2·2	.....	.....	35·5
Average	5·8	9·3	6·7	7·4	0·7	*	.....	.....	*	3·9	7·1	7·8	48·7
Total rain and melted snow	0·58	0·93	0·68	1·31	1·75	3·62	2·57	1·90	1·43	1·65	0·77	0·78	17·97

NUMBER OF DAYS OF RAIN.

1881	0	0	0	5	15	16	11	14	18	4	1	0	84
1882	0	0	0	3	10	10	9	6	2	9	0	0	49
1883	0	0	0	1	6	15	13	7	3	10	0	0	55
1884	0	0	0	4	2	9	17	12	17	4	1	0	66
1885	0	1	0	8	10	9	18	15	5	3	1	0	70
1886	0	0	0	7	13	15	12	11	9	6	0	1	74
1887	0	0	0	4	12	15	13	12	11	3	2	0	72
1888	0	0	0	3	8	12	15	10	10	9	0	0	67
1889	0	0	4	6	13	9	5	4	9	3	1	0	54
1890	0	0	0	5	14	14	13	14	12	16	0	0	88
Average	0	R.	R.	5	10	12	13	10	10	7	1	R.	68

NUMBER OF DAYS OF SNOW.

1881	4	16	6	5	0	0	0	0	0	5	11	5	52
1882	9	3	5	5	1	0	0	0	0	2	9	6	40
1883	4	3	3	3	1	0	0	0	1	5	12	7	39
1884	10	9	7	9	0	0	0	0	0	7	7	10	59
1885	8	7	13	8	4	0	0	0	0	6	5	13	64
1886	13	12	14	2	2	0	0	0	1	1	8	4	57
1887	10	12	9	5	3	1	0	0	0	7	9	12	68
1888	10	9	12	7	2	0	0	0	0	6	9	6	61
1889	13	7	5	2	1	0	0	0	1	2	7	9	47
1890	8	12	12	3	5	0	0	0	1	2	0	0	0
Average	9	9	9	5	2	*	0	0	*	4	9	8	55

STATISTICS of Temperature and Precipitation at Russell, Manitoba, Latitude North 50° 42', Longitude West 101° 20', height above sea 1,830 feet.

BY PROF. C. CARPMAEL.

AVERAGE MONTHLY TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1883									48·00	32·60	11·90	2·80	
1884	- 9·35	10·74	9·40	32·22	53·35	62·07	58·33	59·34	46·20	35·87	16·38	9·24	28·65
1885	- 13·67	- 7·70	13·01	34·66	48·32	57·06	61·07	55·08	48·54	33·69	24·54	8·33	30·24
1886	- 18·16	0·94	11·99	38·80	51·74	60·05	66·93	59·70	44·85	40·27	14·79	4·38	30·63
1887	- 15·82	- 11·71	11·42	34·56	52·51	59·80	62·17	1·53	49·98	31·41	16·35	2·30	28·23
1888	14·46	- 4·77	1·83	28·51	45·01	58·89	62·07	5·44	50·36	36·98	17·50	16·72	29·51
1889	4·87	- 2·67	24·86	41·48	48·04	59·82	60·57	63·20	46·29	36·32	19·87	4·17	33·90
1890	- 14·94	-11·33	6·07	33·86	49·70	62·77	61·18	55·74	46·80	38·47			
Average	- 11·65	6·85	11·23	34·87	48·52	60·09	61·76	58·00	47·63	35·70	17·33	1·50	29·84

AVERAGE MONTHLY MAXIMUM.

1883									63·5	40·8	21·5	6·4	
1884	1·7	— 1·5	20·4	41·4	67·2	73·8	68·7	72·4	56·9	46·7	24·1	0·6	
1885	— 4·9	2·4	21·1	44·3	60·5	69·2	71·4	67·9	64·6	46·5	32·2	18·5	
1886	9·1	13·0	23·6	50·2	64·9	72·8	80·3	74·7	59·6	53·6	37·8	5·2	
1887	- 4·4	0·8	22·2	46·3	66·3	70·9	74·0	70·8	64·4	44·4	28·6	7·9	
1888	— 4·9	8·0	12·6	37·5	57·9	70·3	72·6	71·0	64·8	45·9	27·4	21·2	
1889	14·9	11·4	26·6	54·7	62·0	75·4	75·5	79·2	61·4	51·6	31·8	15·5	
1890	— 5·1	1·2	15·5	44·5	52·3	75·7	75·4	68·4	60·8	48·2			
Average	0·9	5·0	21·7	45·6	61·6	72·6	74·0	72·1	62·0	47·2	27·6	10·7	

1889	14·3	11·4											
1890	— 5·1	1·2	15·5	44·5	52·3	75·7	75·4	68·4	60·8	48·2			
Average	0·9	5·0	21·7	45·6	61·6	72·6	74·0	72·1	62·0	47·2	27·6	10·7	

AVERAGE MONTHLY MINIMUM AND MEAN DAILY RANGE.

1883									32·5	25·3	0·7	— 12·5	
1884	— 20·7	— 23·7	— 0·9	21·3	37·0	49·2	45·1	46·0	35·8	24·2	7·2	— 16·5	
1885	— 24·9	— 17·7	0·1	24·0	34·0	42·1	49·3	42·3	33·7	23·6	16·9	— 4·1	
1886	— 27·9	— 12·3	0·1	25·7	36·1	45·6	50·8	44·3	30·4	28·4	3·2	— 13·9	
1887	— 26·6	— 23·1	2·1	23·0	37·7	46·4	44·2	44·3	36·0	18·4	4·5	— 12·6	
1888	— 24·7	— 15·4	— 10·0	17·9	29·5	45·1	49·0	43·2	37·1	26·9	7·5	1·1	
1889	— 8·4	— 17·6	11·9	27·5	32·7	42·6	46·1	46·5	32·5	24·7	5·7	— 8·3	
1890	— 25·6	— 25·4	— 8·9	21·7	27·8	47·9	48·2	43·1	33·7	30·6			
Average	— 22·7	— 19·3	— 0·8	23·0	33·5	45·6	47·5	44·2	34·0	25·3	6·5	— 9·5	
Mean Daily Range	23·6	24·3	22·5	22·6	28·1	27·0	26·5	24·9	28·0	21·9	21·1	20·2	24·22

HIGHEST TEMPERATURE REGISTFRED.

1883									81·5	63·5	47·0	38·0	
1884	29·5	35·0	41·0	65·0	89·5	92·5	80·5	89·5	72·5	73·5	45·0	40·0	92·5
1885	25·0	37·0	37·0	66·0	79·0	89·0	86·5	81·0	81·0	73·0	45·0	34·0	89·0
1886	19·0	43·5	40·5	75·5	85·5	88·0	95·0	103·7	87·0	81·0	57·5	34·9	103·7
1887	20·0	22·5	41·5	78·5	92·5	82·5	88·0	83·5	80·5	80·5	61·0	38·0	92·5
1888	33·0	39·0	36·0	62·0	76·0	94·0	81·5	86·5	78·0	77·5	46·5	41·0	94·0
1889	30·0	41·5	63·0	74·5	75·5	101·0	90·0	93·0	88·0	80·9	54·5	30·0	101·0
1890	25·0	33·0	31·0	65·0	70·5	90·0	92·0	86·5	85·5	79·0			92·0
Average	25·9	35·9	41·4	69·5	81·2	91·0	87·6	89·1	81·7	76·0	50·9	36·6	95·0

LOWEST TEMPERATURE REGISTERED.

1883									8·7	9·5	— 32·0	— 42·5	
1884	— 48·6	— 43·0	— 30·0	1·0	19·0	37·5	30·5	33·5	26·0	— 4·0	— 31·5	— 45·0	— 48·0
1885	— 44·6	— 44·0	— 25·5	5·0	12·5	25·0	35·5	27·5	25·0	2·0	— 21·5	— 21·5	— 44·0
1886	— 49·0	— 43·0	— 23·0	— 9·0	22·0	32·0	35·5	31·0	13·5	12·0	— 21·5	— 33·2	— 49·0
1887	— 42·5	— 46·0	— 31·0	— 4·0	22·0	28·5	35·0	31·5	21·0	— 11·0	— 34·5	— 30·0	— 46·0
1888	— 47·5	— 49·5	— 30·0	— 7·5	11·5	27·0	38·5	24·5	23·0	11·5	— 21·5	— 17·0	— 49·5
1889	— 32·0	— 49·0	— 15·5	16·5	19·0	34·5	34·0	31·5	18·0	6·0	— 21·0	— 27·5	— 49·0
1890	— 39·5	— 50·0	— 35·0	— 1·5	16·0	37·0	37·0	30·0	7·5	19·5			— 50·0
Average	— 43·4	— 46·4	— 27·1	0·1	17·7	31·6	35·1	29·9	17·2	6·1	— 22·9	— 31·0	— 47·9

STATISTICS of Temperature and Precipitation at Russell, Manitoba.—*Continued.*

RAINFALL IN INCHES.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1883	0·00	0·00	R.	0·00	2·70	2·30	1·63	1·94	0·65	2·30	0·00	0·00	11·52
1884	0·00	0·00	0·00	·28	0·30	3·42	1·90	1·35	2·11	0·55	0·02	0·00	9·93
1885	0·00	0·00	R.	·80	1·05	6·86	4·03	2·57	0·30	R.	0·00	0·00	15·61
1886	0·00	R.	0·00	·69	1·70	2·32	1·95	1·64	0·42	1·76	R.	0·25	10·67
1887	0·00	0·00	0·00	·10	2·31	5·99	2·51	2·85	2·18	0·20	R.	0·00	16·14
1888	0·00	0·00	0·00	·06	0·50	6·25	4·25	1·98	0·52	0·21	0·00	0·00	13·77
1889	0·00	R.	0·27	·12	1·21	0·52	1·60	0·68	0·92	0·02	R.	0·00	5·34
1890	0·00	0·00	0·00	·78	1·59	2·03	2·54	4.82	2·01	1·82	.....	.....	15·59
Average	0·00	0·00	0·03	0·35	1·42	3·71	2·55	2.23	1·14	0·85	R.	0·04	12·32

SNOW IN INCHES AND TOTAL PRECIPITATION.

	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1883	.....	.....	.....	.....	.....	.....	.....	.....	0	0·5	8·7	5·9	
1884	5·5	10·0	10·0	3·0	0	0	0	0	0	5·5	5·5	9·3	48·8
1885	2·5	4·0	7·0	18·6	2·5	0	0	0	0	8·5	1·5	9·5	54·1
1886	5·0	6·8	11·5	6·0	1·0	0	0	0	0	1 ·	4·0	2·6	37·3
1887	5·3	7·3	4·0	5·3	*	0	0	0	0	3·9	6·3	13·5	44·7
1888	5·5	8·5	17·5	8·5	0·5	0	0	0	0	9·5	5·5	4·0	59·5
1889	5·5	5·3	0·7	3·0	2·0	0	0	0	0·5	*	3·5	12·0	32·3
1890	4·5	15·5	8·3	1·5	6·0	0	0	0	5·0	1·8	.....	.....	42·6
Average	4·7	8·2	8·4	6·6	1·7	0	0	0	0·8	4·3	5·0	8·2	47·9
Total rain and melted snow	0·47	0·82	0·87	1·01	1·59	3·71	2·55	2·23	1·22	1·28	0·50	0·86	17·11

Average	4·7	8·2	8·4	6·6	1·7	0	0	0	0·8	4·3	5·0	8·2	47·9
Total rain and melted snow	0·47	0·82	0·87	1·01	1·59	3·71	2·55	2·23	1·22	1·28	0·50	0·86	17·11

NUMBER OF DAYS OF RAIN.

1883	0	0	1	0	9	15	13	9	4	11	0	0	62
1884	0	0	0	5	2	14	17	12	18	5	1	0	74
1885	0	0	1	6	10	13	16	14	7	3	0	0	70
1886	0	1	0	5	8	7	9	9	9	5	1	2	56
1887	0	0	0	4	15	14	11	10	7	2	2	0	65
1888	0	0	0	2	7	11	9	6	11	3	0	0	49
1889	0	1	2	7	9	7	13	5	8	4	1	0	57
1890	0	0	0	7	13	14	14	12	11	8	.....	.....	79
Average	0	0	1	4	9	12	13	10	9	5	1	R	64

NUMBER OF DAYS OF SNOW.

1883	.....	.....	.....	.....	.....	.....	.....	.....	0	1	10	9	.....
1884	14	10	10	3	0	0	0	0	0	5	9	9	60
1885	7	9	14	8	2	0	0	0	0	9	6	13	68
1886	14	9	15	3	4	0	0	0	0	3	7	6	61
1887	11	12	9	5	1	0	0	0	0	10	10	14	72
1888	8	8	12	5	2	0	0	0	0	3	5	7	50
1889	10	4	2	2	1	0	0	0	1	2	7	9	38
1890	6	8	8	4	9	0	0	0	2	5	.....	.....	.....
Average	10	9	10	4	3	0	0	0	*	5	8	10	59

THE LACUSTRAL PLAIN.

This plain presents a slightly undulating surface which extends from the foot of the Manitoba escarpment to the east shore of Lake Winnipeg. It is thinly covered with alluvial or glacial deposits, through which the underlying limestones occasionally project and form islands or cliffs on the lakes, or more or less conspicuous hills inland. The depressions in the surface of this plain are filled with lakes that vary much in size and contour. The following are the most important of these embraced within the scope of this report :—

Manitoba, Ebb and Flow, Partridge Crop, Winnipegosis, Waterhen, Swan, Pelican, Red Deer, Cedar and Cross Lakes, together with a number of small lakes in the totally unexplored region east of Lake Winnipegosis. The plain can be best described in connection with the larger bodies of water on its surface.

LAKE MANITOBA.

Position. Lake Manitoba lies between latitudes 50° 11′ and 51° 48′ north, and longitudes 97° 56′ and 99° 35′ west, extending in a general direction N. 25° W.

Altitude. Its mean altitude above the sea is 810 feet, as shown by the profiles of the original location of the Canadian Pacific Railway. This railway survey line was run in the winter of 1874–75, and the difference between high and low water at Sifton Narrows, where the line crossed the lake, is given in the profile at two feet. The high water in Lake Manitoba is given by the same profile as ninety-nine feet above the level of the ice crossing of Red River, near the village of West Selkirk, or eighty-eight feet above the level of the water mark of the freshet of 1852. This latter point is given by J. H. Rowan, C.E.,* one of the engineers of the old location at 16·55 feet above the mean level of the water in Lake Winnipeg. The height of Lake Winnipeg is 710 feet above the sea, and therefore the high water at the Narrows of Lake Manitoba as determined in the winter of 1874–75 is 104·55 feet above Lake Winnipeg or 814·55 feet above the sea. The low water is put at only two feet below high water, which is much less than it should be, since in 1881, Mr. Guerin† found the lake to be six feet above its normal low water level. As 1874 and 1875 were years of rather high water, four and a half feet may be taken from the high water mark then observed, thus giving 810

* The Red River, by James H. Rowan. Transaction 13, Man. Hist. & Sci. Soc., Winnipeg, 1874.

† Public Works Report, 1867–1882.

feet as the mean height of the lake as stated above. This agrees closely with the height given by Mr. Upham* for the mean altitude of the same lake.

Extent.

The lake has a total length of 119 miles, and is divided into two parts by a strait known as "The Narrows" which, to distinguish it from other places with the same local appellation, might be known as "Sifton Narrows," from Mr. Sifton who has kept a trading store at this place for some years. The channel here contracts to a width of 2,650 feet with a maximum depth of fifteen feet. This strait divides the lake into two distinct portions differing widely in their physical features. The southern portion is sixty-three miles long, and twenty-nine miles wide in its widest part, and has generally a moderately even regular contour, with very few islands, except immediately south of Sifton Narrows. The shore line of this portion amounts to 160 miles and its total area to 1,039 square miles.

Southern portion.

Northern portion.

The lake north of the Narrows is very different from that to the south. It is cut by long stony points into deep bays, and while the total length is only fifty-six miles, the length of shore line is 375 miles, and the total area is only 672 square miles. The greatest depth found in this northern portion is twenty-one feet six inches, and the average depth of the middle of the lake east of Crane River Narrows is about sixteen feet. The southern expansion of the lake is reported to have about the same general depth. The mean depth of the lake may therefore be assumed at twelve feet, and as its total area is 1,711 square miles, its total capacity is about 572,399,308,800 cubic feet.

Rise and fall of water.

The only considerable streams flowing into the lake are White Mud River at its south end, and Waterhen River at its north end. These were measured by Thomas Guerin in the summer of 1881, and were found to be then discharging respectively 1,425 and 13,930 cubic feet of water per second, while at the same time the Fairford River was discharging from the lake 14,833 cubic feet per second. This would leave a surplus in the lake, to be removed by evaporation, of 522 cubic feet a second or 45,100,800 cubic feet a day, and other small tributaries would probably bring this surplus up to 60,000,000 cubic feet a day, or only ·01 of an inch over the whole surface of the lake. By consulting the table of rainfall given above, it will be seen that the mean rainfall for the three months of June, July and August is 8·09 inches, or ·088 inches a day, and this added to the ·01 inch obtained above would give ·098 inch a day as the mean daily evaporation from the

* Report of Exploration of the Glacial Lake Agassiz in Manitoba by Warren Upham. Geol. Surv. of Can. Ann. Rept., Vol. IV., p. 155 E.

surface of this lake. It is not improbable, however, that the surplus water left in the lake is greater than that given above, and Mr. Guerin's experiments at Fairford on evaporation would appear to indicate that this was the case, as for the month of August, 1881, he found that the amount of water evaporated from a shallow vessel was about 5¼ inches. In that year also the channels of the above named three rivers were filled well up to their brims, while in 1888 and 1889 the water was low and there was a drop of several feet from the brink of the channel to the surface of the stream.

Periods of high and low water.

Periods of high and low water occur at apparently long and irregular intervals, and are caused by excessive rainfall and excessive drought. In general, however, the lakes may be said to oscillate about a foot above or below the normal. In 1880 the lake was very high, whereas in 1889 it was very low. In 1858 Professor Hind* states that the water was two feet above its lowest level, that in 1852 there was a period of very high water, previous to which for a long time the water had been very low. In 1826 there was another period of high water, anterior to which there would appear to be as yet no very definite published record.

Wind.

The winds have a very marked effect on the height of the water at any particular place on the shore of this, or of the adjoining shallow lakes. With a wind blowing from the north-west or south-east, the water is driven towards the opposite end of the lake, and the lake being so shallow, the undertow is not able to form a continuous current beneath the surface. The water, blown forward by the wind, can return only by a series of interrupted undercurrents which are incapable of preventing it from being piled up at the extremity of the lake towards which the wind is blowing.

Temperature

On account of the shallowness of the water, its temperature is comparatively high during the summer months, and this large body of warm water exerts a very great influence in reducing the daily range of temperature and thus preventing summer frosts.

On page 47, will be found a list of observations on the temperature of the water of Lake Winnipegosis during the summer and autumn of 1889, and it is probable that the temperature of Lake Manitoba will average slightly higher.

Record of the freezing and thawing of the lake.

The lake annually freezes over, but no exact records have up to the present been systematically kept of the date in the autumn when it first becomes covered with ice, or of the date in the spring when the ice breaks up and again opens the lake for navigation.

* Report on the Assiniboine and Saskatchewan Exploring Expedition. 4to. Toronto, 1859, p. 102.

Record of the freezing and thawing of the lake.

The following extracts have been taken from the "Journal of Occurrences" kept at the Hudson's Bay Company's Post of Manitoba House, on the west side of the lake, and are published with the permission of Mr. Joseph Wrigley, Commissioner of the Company :

Oct. 23, 1881. Ice all disappeared.

Nov. 3, 1881. Lake frozen about the shores.

" 10, 1881. Lake frozen fast as far as the eye can see.

May 13, 1882. The lake is now open in places along the shore.

" 16, 1882. Ice moved a little north.

" 17, 1882. Ice breaking up rapidly.

" 18, 1882. Ice drifting north, large spaces of open water to be seen in every direction.

May 20, 1882. No ice to be seen as far as the eye can reach, so that it may be said *the lake is now open.*

May 22, 1882. Small boat passed en route to Totogen.

" 17, 1883. Ice seems to be much broken up, and open water is to be seen in many places.

May 18, 1883. The wind veering to the north in the afternoon, the ice began to break up and drift to the south, so that at 6 p.m. the bay was clear.

May 19, 1883. No ice is to be seen, so that navigation is open.

Nov. 1, 1883. Ice forming rapidly along the shores.

" 5, 1883. Boat passed to Totogen.

" 6, 1883. Froze hard last night, so that the lake opposite is nearly all frozen over. Outer lake, except bays, still open.

Nov. 7, 1883. Outer lake open.

" 9, 1883. Beyond the village the lake is still open.

" 10, 1883. The lake is to-day, as far as the eye can reach, all fast with ice.

May 12, 1884. Ice moved a few yards southward to-day.

" 16, 1884. Spaces of open water to be seen on east shore.

" 17, 1884. N.-E. wind cleared the bay of ice.

" 19, 1884. No ice to be seen.

Oct. 27, 1884. All the lake closed in with ice as far as the eye can see.

May 13, 1885. Open patches of water to be seen.

" 16, 1885. Ice moving about.

" 18, 1885. Lake clear of ice.

Nov. 1, 1885. Ice to be seen on the bay this morning, a thin skim covering the whole bay.

Nov. 2, 1885. The whole lake, as far as can be seen, frozen over.

" 7, 1885. The lake found to be still open on the other side.

Record of the freezing and thawing of the lake—*Con.*

April 30, 1886. Open water to be seen right across to Sugar Island.
May 6, 1886. Schooner passed to Totogen.
Nov. 5, 1886. Thin skim of ice over portions of the bay.
" 16, 1886. Lake all frozen over.
May 7, 1887. Ice moved a little.
" 14, 1887. The lake clear of ice.

The following information was obtained from Mr. McKay, J.P., who has lived by Lake Manitoba for many years.

For the opening of the lake :

In 1889. April 18th, the earliest known.

In 1866. May 20th, the latest known.

The average would be from the 10th to the 15th of May.

The lake frozen over :

In 1883. October 18th, the earliest date known in thirty years.

In 1874. November 13th, the latest date known in thirty years.

In 1871. Commenced to freeze on October 24th, but was not frozen over till November 2nd.

The average date of the closing of York boat navigation is about October 28th.

The water in the lake throughout the summer is slightly milky, from the presence of fine clayey material in suspension, which is stirred up by storms from the low shores and the soft, shallow bottom.

Shores and Islands.

Southern expansion of lake.

The southern expansion of the lake lies almost entirely beyond the limit of the accompanying map, but its western side was examined when proceeding from Westbourne, where the expedition started in 1888, and was found to be composed very largely of a low sand or gravel beach behind a soft clay shore studded with boulders. Behind the beach is a level country, often marshy, extending back to a forest of poplar or spruce. At Manitoba House the shore is higher, sloping up to a gravel ridge in a narrow belt of timber.

Manitoba House.

The Hudson's Bay Company's trading post of Manitoba House is beautifully situated on this slope, and looks out over a narrow streak of water towards some islands thickly wooded with poplar and maple, to which the Indians annually resort in the spring to boil down the sap of the latter tree for sugar.

Mr. David Armitt, who was in charge of the trading post in 1889, informed me that the present house was built by Ewan Macdonald in 1870, and that the house which was being built by Mr. McKenzie in 1858, when the place was visited by Mr. H. Y. Hind, was about 300 yards further south, where the ruins can still be seen.

Between Manitoba House and Sifton Narrows, the shores, both of the islands and the mainland, are low, and usually protected by a shingle beach of irregular, waterworn limestone pebbles, behind which stretch woods of poplar, willow, and occasionally ash-leaved maple. One point, north of the creek into Ebb and Flow Lake, is composed of Archæan boulders, and other parts of the shore are low and marshy.

Sifton Narrows.

On the west side of Sifton Narrows, is the Indian agency, and a trading store kept by Mr. Sifton. A quarter of a mile south from this store, in the extreme south-west corner of section 22, township 24, range 10, west of the Principal Meridian, is the site of some old buildings which, the Indians informed me, were formerly a trading post of the Hudson's Bay Company. Nothing now remains but a small chimney-mound and three hollows in the midst of a grove of willows, between which and the edge of the lake is a grassy meadow 120 yards wide, and level to near the edge of the water, where it is bounded by a gravel ridge. To the west the land is still level, but covered with small poplar, mixed with a few small ash and elm.

North of the Indian agency the shore is at first soft, but it soon becomes skirted by a gravel bar which extends to an outcrop of compact Devonian limestone.

Manitoba Island.

To the east of this rock outcrop, and at the north end of the strait, is Manitoba Island, with an area of about 160 acres, and rising from fifteen to twenty feet above the water. Its interior is either wooded with poplar and birch, or is open and grassy, or covered with underbrush of amelanchier and choke cherry. On the shores elm is also growing to a large size. While the east and west sides of the island slope more or less gradually to the water, the north side presents an abrupt cliff of limestone twelve feet high, from the foot of which a talus of limestone gravel fifty feet wide slopes to the lake. The limestone is very compact and resonant, and when the waves beat against this beach and throw these resounding pebbles one on another, the roaring sound will undoubtedly be produced which has given rise to the superstition among the Indians that a Manito or Spirit beats a drum or otherwise makes a noise on the island. The strait past the island was therefore called Manito-wapow (*Cree*), or Manito-baw (*Ojibway*), meaning the Strait of the Spirit or Manito.

Horseshoe Harbour.

At the west end of the cliff the gravel beach runs out into deep water, and incloses a beautiful little harbour, known as Horseshoe Harbour, where the small freighting boats can find shelter on their way up and down the lake.

Following the east side of the lake northward from Manitoba Island the shore line is indented by deep marshy bays, surrounded by low

country, either marshy or wooded with poplar and some spruce, while the points, which are also not more than a few feet above the water,

Point Richard

are generally guarded by a wall of Laurentian boulders. Point Richard is of this character, and off it are some small bare islands, consisting of bars of sand and small limestone gravel scattered over with large boulders of gneiss and cream-coloured limestone. To the northward lies Reed Island, wooded in the interior and apparently surrounded by a white sandy beach.

Dog-hung Bay

East of Reed Island is a deep rounded bay, known as Dog-hung Bay, extending beyond the eastern confines of the map. The prominent points in this bay are all composed of boulders piled in an even slope to a height of six or eight feet above the lake, while between the points is a beach of rounded limestone gravel, on which is growing a narrow belt of poplar, elm and oak. Behind the points are often small ponds, and in rear of the whole beach is an extensive open marsh, stretching back to a forest of poplar and spruce. A belt of low land is said to extend north-eastward from this bay towards Lake St. Martin, and in years of very high water this belt is entirely overflowed.

North of Dog-hung Bay, the shore maintains precisely the same character to Elm Point, which is itself a ridge or spit of limestone gravel without boulders, projecting out into the deep water of the lake, and overhung by a number of fine elm trees. North of this point the shore is more regular, without so many boulders on the points, and for a considerable stretch the drier wooded country comes to the edge of

Steep Rock Point.

the lake, but boulders are backed up against it in a close wall. Then limestone cliffs begin to make their appearance, and continue for a couple of miles along the shore, rising at their highest point to twenty-two feet above the water. The bottom of these cliffs is hollowed out into fantastic shapes, and on their summit is a lovely stretch of open prairie, in places overshadowed by oak trees. This is one of the most charming camping places on the lake.

Low Island.

Off the cliff is a small wooded island, composed of flat-lying limestone and boulder clay.

From the neighbourhood of these limestone cliffs, to the mouth of Fairford River, the shore is low, and generally bordered by a gravel ridge.

Fairford River.

Fairford or Partridge Crop River discharges Lake Manitoba through Partridge Crop Lake into Lake St. Martin, and this in its turn is discharged by St. Martin or Little Saskatchewan River into Lake Winnipeg. It has a width of 700 to 900 feet, and a channel from ten to twenty feet deep. Where it leaves the lake it flows over a bed of flat-lying limestone, on which there is usually from two to three feet of

water, but after crossing this bar its banks are composed of hard, light gray clay, with a few boulders, till it passes the Mission and reaches the shallow expansion now largely covered by the water of Partridge Crop Lake. From this lake it again flows between clay banks, but in a shallow channel, to Lake St. Martin. It has a total length of ten miles, and a total fall, in this distance, of about fifteen feet. Most of the fall occurs in two rapids, one a short distance below Partridge Crop Lake, and the other a mile and a third in length, between Fairford Mission and Lake Manitoba. These are chiefly caused by the collection in the bed of the stream of great numbers of boulders of gneiss and limestone, washed out of the contiguous banks of boulder-clay.

On its upper portion the north bank of the river is generally thickly wooded with poplar, while the south bank shows several small clearings around comfortable log houses. Here are also situated the trading post of the Hudson's Bay Company and the Church of England mission, the former, a mile and a half, and the latter two miles and a half, from Lake Manitoba. The mission was first established on the less thickly wooded gravelly banks of the river below Partridge Crop Lake, but on account of floods the situation had to be abandoned, and the church and parsonage are now beautifully situated on a rising ground from twenty to thirty feet above the river, and overlooking, towards the south, a forest of poplar, spruce, and Banksian pine. Fairford Mission.

Returning to Lake Manitoba and proceeding northward from the mouth of Fairford River the shore as far as Davis Point is generally rather low, in some places bounded by a gravel bar, and in other places it is high enough to be wooded with poplar and birch down to the beach. In the distance tall spruce trees can occasionally be seen. The point itself is composed of thick-bedded white limestone. Davis Point.

West of Davis Point, the north shore of Portage Bay is cut by deep narrow bays separated by long points wooded with elm and poplar. These points run out in a direction a little east of south, on the same course as the glacial striation, and are composed chiefly of large boulders of Laurentian gneiss, mixed with a very few of palæozoic limestone. Portage Bay.

Paonan Peninsula, as far as it was examined, was also found to be low, and surrounded by a wall of Archæan boulders, behind which, in the more southern parts, is a marsh extending back to a poplar forest; while in its northern half the woods generally come down to the beach. Across the north end of the peninsula is a portage road 1,700 paces in length, over which the Indians often carry their canoes. At the east end of the portage, which is opposite a small island of boulders covered with a few willows, the water is very shallow, and the first few hundred yards of the portage itself are across a sloping gravel plain, extend- Paonan Peninsula.

ing from the water to the poplar woods. The western end of the portage is in a grove of oaks, at the bottom of a small bay opening to the south, the shores of which are sandy and piled with boulders.

West of Paonan Peninsula a long shallow bay runs to the northward. The north end of this bay is especially shallow, with stones projecting above the water in every direction, and banks of rushes growing off the beach. The surrounding country is wooded with small poplar, while spruce and tamarack can occasionally be seen in the distance.

Garden Island.

Garden Island, which lies just off the point west of the mouth of this bay, is a ridge of gravel and boulders, inclosing, in the northern part, a grassy and reedy marsh, and in other places drier land. It is wooded all around the shore, and, in the southern part, in the interior. On its western side a sand bar runs out towards the point of the main shore. The island is said to have derived its name from the fact that Indians of the Crane River band used to grow crops of potatoes here year after year.

Crane River Narrows.

West of Garden Island Point, two long points extend southward towards the opposite shore, contracting the lake in one place to less than a mile and a half in width, and from these points extend boulder-reefs, in places piled up into little islands, on which a few willows may be growing. Thus this strait is shallow and much obstructed by boulders, so that, in low water, it is difficult to find a channel through it four feet in depth. The boulders are almost all of granite or mica-schist, while many of the pebbles on the shore are of white palæozoic limestone.

Low shore.

Between Elm Point, the most westerly of the two points above mentioned, and the mouth of Waterhen River, the shore is all composed of sand or boulders, and, like the north shore of the lake elsewhere, without any sign of fixed rock. The boulders at and near the points are piled in steep walls six to eight feet in height, and behind these walls are often groves of large elms and maples.

Twin Islands.

From the mouth of Waterhen River southward for a few miles the shore was not closely examined, but it appeared to be low, and without special interest. Off the mouth of the river lie the Twin Islands, two low islands thickly wooded with poplar and elm, with a few spruce in the interior. The islands are surrounded by a beach of gravel or boulders about seven feet high, and are connected by a bar of limestone gravel half a mile long, which rises five feet above the water and has an average width of 100 feet. At the north end of this bar is a large, cairn-like heap of boulders piled up by the ice.

South of Twin Islands another similar island, wooded with poplar and ash, lies close to the shore, and is connected with it by a very similar bar of sand and fine gravel more than half a mile long, rising in some places not more than a foot above the water, and averaging only about thirty-five feet in width.

From the end of this bar to Onion Point the shore is low and sandy or scattered with boulders, but at the point itself a cliff of limestone, eight feet in height at its highest point, looks out in a north-westerly direction over the lake. On the top of the rock is a little oak-surrounded prairie, similar to that at Steep Rock Point already referred to, but not quite so large or open. Onion Point.

The next two prominent points are composed of limestone, and the shores of the bays are thickly wooded with poplar. At Little Sandy Point there is a pile of rounded granite boulders, and just to the eastward is a high spit of sand and small rounded limestone gravel, at which the York boats usually stop on their way up the lakes, as the water is here moderately deep up to the shore. Little Sandy Point.

From Little Sandy Point to the limestone cliff at Monroe Point the shore is generally low, and more or less thickly wooded with poplar. East of Monroe Point a small brook, known as Crane River, enters the lake from the south, but it appears to carry very little water. It is quite stagnant for about a mile from the lake, to a point where there is a small Indian village, composed of a few log houses tenanted only in winter. Crane River.

The east shore of Crane Bay is generally piled with boulders, while the extreme point is a high ridge of boulders extending out into the lake, on the end of which a few elms, maples and willows have grown. A quarter of a mile to the south, this ridge divides; the branches run back and include a marsh about a mile in length and a quarter of a mile in width. The other points south of Crane River Narrows are also composed largely of boulders, and the bays between them are shallow and marshy.

South of Crane River Narrows the shore assumes a much more even character, since the lake here extends for twenty-five miles in the direction of the general glaciation of the country, and therefore no drumlin-ridges of boulders extend out at right angles to the shore. As a rule, the water is moderately deep to within a short distance of the land. The beach in some places runs back to a ridge of boulders, but it generally consists of a bar of limestone gravel in front of a wide, level marsh, behind which are groves of poplar. It was reported that the country to the west, and for a considerable distance inland, is made up entirely of alternating bands of marsh and poplar woods extending in Even shore.

a north and south direction. The best known harbour on this shore is at Big Sandy Point, which is a spit of sand and limestone gravel running out into deep water, just south of some low cliffs of white limestone. The harbour is not a good one, being open to the north-east wind, but the deep water close to the gravel beach makes it a convenient place to land.

Big Sandy Point.

Near the southern end of this portion of the lake are three islands, two of them being merely piles of boulders quite bare of vegetation, while the third and largest is low and generally marshy, but bears a few bushes, and is surrounded by bars of gravel and calcareous sand, with boulders of gneiss on the points. The most westerly of the small stony islands was visited on the 4th of August, 1888, and was found to be black with great numbers of cormorants (*Phalacrocorax dilophus*), young and old, this being their principal breeding place in the lake. North-east of these islands, and at the south-eastern extremity of this stretch of open water, the lake is again shallow and contracted, the space between the point of Paoman Peninsula and the opposite shore being largely taken up by Cherry Island. The water in the main channel to the south of this island is not more than seven feet deep, while to the north of it a depth of three feet is all that was found throughout.

Cormorants.

Cherry Island possesses a [illegible] harbour on its north-east side where the brigades of freighting boats belonging to the Hudson's Bay Company, coming from various parts of this district, used to wait for each other before proceeding on their annual trip to York Factory. The name Paonan, now given to the peninsula to the north, is said to be an Ojibway word meaning "Waiting place," and was originally applied to this harbour. The harbour is a little horse-shoe-shaped bay, open to the north and north-east, but obstructed at its mouth by a sandy bar. The water within this bar is from four to five feet deep up to the beach of sand and gravel, which rises six feet above the water. Behind the beach is a narrow sandy plain, behind which is a thin row of elm, oak, maple and cherry. The centre of the island is a marsh covered with tall reeds, while most of the rest of the shore is surrounded by reeds or boulder-bars running out a considerable distance into the lake. Riding Mountain can be distinctly seen from this island as a clear blue line in the south-west.

Cherry Island.

South of Cherry Island the west side of the lake to the Narrows is low, and without any sign of the underlying rock, but is composed of a ridge of gravel or boulders, lying on an original floor of boulder-clay, which has been first shoved up by the ice, and then assorted by the waves and currents. Many examples of

West shore north of Narrows.

the result of the shoving of spring or floating ice were seen in 1889 in the little mounds of clay and gravel near the water's edge on the gently sloping shore just in front of the ridge of boulders; and the gravel hook at the "Bluff Harbour" is an excellent example of the way in which this ice-shoved material is assorted by waves and currents, the finer pebbles being carried along into deeper water. Bluff Harbour.

WATERHEN RIVER AND LAKE.

Waterhen River flows from Lake Winnipegosis into the north-western extremity of Lake Manitoba, touching the south end of Waterhen Lake about the middle of its course. Its Indian name, *Sin-gip-siew sibi*, is given to it on account of the presence here of the western grebe (*Podiceps occidentalis*, Ojibway *Sin-gip-siew*), which breeds on the lake and river in quite large numbers. Name.

The river was examined and surveyed by Henry B. Smith, C.E., in 1873, and the following are some of his notes in reference to it: Description by H. B. Smith.

"The total distance by this river between the above lakes (Winnipegosis and Manitoba) is thirty miles, and the difference of level 18·73 feet. After traversing a long reach of Lake Winnipegosis, the Waterhen River is entered, flowing in a north-easterly direction between low marshy banks, with a current of three miles an hour over a muddy bottom; its average width is about 500 to 600 feet and depth five to six feet: the difference of level on this section, known as the 'North Branch,' is about six feet.

"Waterhen Lake is now reached, a very shallow sheet of water, filled with boulders lying on a stiff clay bottom, and so close together that no channel can be found; the average depth (in the channel) in July, 1872, was only three feet.

"Leaving Waterhen Lake the river flows at an average rate of from three to four miles an hour in a southerly direction to the 'Forks.' The depth varies from three and a half to seventeen feet, and the channel is in many places obstructed by large boulders, so as to interfere seriously with navigation.

"The average width of this portion of the river is about 500 feet, the bottom is stony as far as the 'Forks,' where it becomes muddy."*

In 1881 Thos. Guerin, C.E., examined the river for the purpose of determining the amount of water discharged by it, and reports as fol- Volume discharge.

*Memorandum on the portages and streams between Lakes Winnipeg, Manitoba, &c. From reports on surveys made by Henry B. Smith, C.E., in 1873. C. P. R. Report, Ottawa, 1874, p. 260, with map and section.

lows :—"About five miles above its junction with the lake (Manitoba) a suitable place was found for examining it. Here the river was 444 feet wide; its maximum depth was twelve feet, and the quantity of water passing in it was 13,930 cubic feet per second. From a watermark visible on its banks it was ascertained that the river had fallen $1\frac{65}{100}$ feet from its highest stage during the previous spring. When it was at that stage, the quantity of water passing in it was 18,642 cubic feet per second."*

River banks. In the upper parts of the river the banks are low, and generally skirted with reeds, though near Lake Winnipegosis the reeds are varied with grassy banks and occasional gravel beaches. At its mouth into Waterhen Lake the river is almost filled with rushes, and through them there is a narrow, rapid stream.

Another channel, to the east of the one usually travelled, is said to exist, but it was not examined.

In the lower part of the river are a number of islands, most of which are surrounded by rushes, and capped in the centre by groves of poplar. The banks are generally from three to eight feet in height, grassy on the face, but on top covered with the burnt remains of a forest of poplar and birch and small oak. Boulders of gneiss are scattered over the surface.

The river empties into Lake Manitoba by several channels, all of which wind through a low wide marsh for several miles.

Waterhen Lake. Waterhen Lake was examined by Mr. Dowling, who states that it is twenty-four miles long, with a width of five miles, a shore line of sixty miles, an area of forty-four square miles, and an elevation above the sea of 822 feet. It is very shallow, the depth in the centre being about six feet. The south-east side of the lake is thickly strewn with large boulders, but further to the north they are not so prevalent, though the beach is still low and sloping, partaking very much of the character of the east shore of Lake Winnipegosis north of Birch Island. The western shore is generally low and muddy, and often indefinite, being bounded by a wide bank of rushes. None of the underlying rocks were anywhere seen.

LAKE WINNIPEGOSIS.

Position. Lake Winnipegosis is a long, curved lake, lying between north latitudes 51° 34′ and 53° 11′, and west longitudes 99° 37′ and 101° 6′.

Extent. Its greatest length in a direction N. 30° W from Meadow Portage to

*Report on Lake Manitoba overflow, by Thomas Guerin. Report of the Minister of Public Works, 1867-1882, p. 541, Ottawa, 1883.

the mouth of Overflowing River, but across a long stretch of land, is one hundred and twenty-two miles; its greatest width, north of Fox Point, is seventeen miles and a half. It has a shore line of 570 miles, an area, exclusive of islands, of 2,000 square miles, while its islands have an aggregate area of ninety-six square miles. Its greatest ascertained depth is thirty-eight feet, off the north-east point of Birch Island, and its mean altitude is eighteen feet above Lake Manitoba, or 828 feet above the sea. This height is the approximate mean of two measurements made respectively by H. B. Smith, C.E.,* in 1873, and George A. Bayne, C.E.,† in 1889, the former finding a difference of level of 18·73 feet between the two lakes, and the latter a difference of 17·4 feet measured across Meadow Portage, when the water had been calm for some time.

Clearer water

The water in this lake is clearer than that in either Lakes Winnipeg or Manitoba, and, as was stated in referring to the latter lake, it is warmed by the sun's rays in summer, and as it does not cool rapidly, it exerts a great influence in equalizing the diurnal temperature of the country in its vicinity, and thus preventing the occurrence of summer frosts.

Water temperature.

The following table will show the temperatures of the surface of the lake and vicinity during the summer of 1889, the observations having been generally taken in open water, some distance from land :—

WATER TEMPERATURE.

Date.	Time.	Temperature.	Remarks.
July 13		62 Fahr.	In Lake Winnipegosis.
14	9.05 a. m.	66	
15	8.00 a. m.	64	
16	8.20 a. m.	65	
18	7.40 a. m.	64	
19	1.40 p. m.	66	
20	8.35 a. m.	65	
21	8.45 a. m.	63	
22	3.15 p. m.	67	
23	11.30 a. m.	68	
24	11.30 a. m.	70	
25	7.00 a. m.	67	
29	10.15 a. m.	70	
31	12.00	70	
Aug. 3	9.00 a. m.	62	
6	8.00 a. m.	66	
7	3.30 p. m.	66	

*Memorandum on the portages and streams, &c., by Henry B. Smith, C. E., C.P.R. Report, 1874, p. 260.

†Letter from George A. Bayne, C.E., of Winnipeg, dated Dec. 26, 1890.

WATER TEMPERATURE—*Concluded.*

Water temperature—*Con.*	Date.	Time.	Temperature.	Remarks.
	Aug. 8	7.26 a. m.	63	
	9	10.00	65	
	10		66	In Red Deer River.
	13		68	do do
	14	6.15 a. m.	70	do do
	14	10.50 a. m.	71	In Lake Winnipegosis.
	15	9.00 a. m.	69	
	17	7.45 a. m.	68	
	18	9.00 a. m.	68	In mouth of Shoal River.
	22	1.00 p. m.	69	In Swan Lake.
	27	5.00 p. m.	69	do
	31	12.30 p. m.	65	do
	Sept. 1	1.50 p. m.	65	do
	2	7.20 a. m.	57	do
	3	2.00 p. m.	59	do
	6	5.30 p. m.	56	In Lake Winnipegosis.
	7	1.30 p. m.	56	
	8	9.00 a. m.	56	
	21	10.00 a. m.	48	
	22	9.30 a. m.	49	
	25	9.30 a. m.	44	
	26	8.30 a. m.	46½	
	27	2.30 p. m.	47½	
	28	11.00 a. m.	45	
	Oct. 1	9.00 a. m.	41½	
	3	9.30 a. m.	41	
	5	8.30 a. m.	41½	
	6	11.45 a. m.	41	
	7	8.15 a. m.	41½	
	10		42	
	12		43	
	14		42	In Waterhen Lake.
	19		40	In Lake Manitoba.
	22			Ice around the shore.

Ice.

The lake annually freezes over with a thickness of from two to three feet of ice, and, as far as could be learned, the dates of the opening and closing of navigation are about the same as those given for Lake Manitoba on pages 37 and 38.

Shores and Islands.

The following brief description of the shores and islands of the lake refers to the summer of 1889 unless otherwise stated.

Beginning at the south-eastern corner of the lake and proceeding northward, the shore is generally composed of a ridge of sand and gravel faced with scattered boulders, behind which is a marsh or low meadow from a quarter of a mile to a mile in width. East of the marsh or meadow is a light gravel ridge, on which are growing oak, willow and poplar, inclosing here and there small grassy swamps.

The Meadow Portage, between Lake Winnipegosis and Lake Manitoba, has its western termination in a little bay in this long coast meadow. The shore of this bay is free from boulders, and is a good landing place for canoes and small boats, but a number of stony reefs lie a short distance out in the shallow water. From the shore the portage road runs east across the level meadow for a quarter of a mile to a belt of oak and poplar. Passing through this grove it skirts the north end of an extensive marsh, passing here and there through clumps of trees, till a belt of poplar woods about a quarter of a mile wide is reached. Beyond this another swamp a third of a mile wide is crossed, and then the road enters a poplar forest stretching down to Lake Manitoba. Within this forest and about a mile and a third from Lake Winnipegosis is a low ridge, stated by H. B. Smith on his profile,* to be eleven feet above Lake Winnipegosis, or 29·72 feet above Lake Manitoba. Mr. Bayne informs me that the shortest distance between the two lakes is 9,400 feet. The land consists of a light gray, almost white, calcareous clay, holding many irregular pebbles of limestone. Very few boulders are lying on the surface, except at a point about two hundred yards east of the ridge last mentioned, where they are rather numerous. Meadow Portage.

The country maintains the same character throughout to the head of Waterhen River. The old trading post of the Hudson's Bay Company was situated on this shore, near the head of the river, but a few years ago it was moved down the river to a point just below Waterhen Lake.

From the head of Waterhen River to Point Brabant the east shore was examined by Mr. Dowling, and the following description is from his notes:— Waterhen River to Point Brabant.

The west side of the bay from which Waterhen River flows is very similar to the east side, being generally bounded by a beach of sand or gravel, behind which is a low flat meadow, extending back to a burnt forest of poplar and spruce. At a point half way down the side of the bay several small saline ponds lie behind the gravel beach, and at Salt Point there is a drier meadow, on which are the remains of several old houses. From this point a reef of boulders extends into the lake towards Ermine Island, which is generally high, and wooded with maple, its northern extremity extending into a gravel bar. Long Island, lying further southward within the bay, is low, and generally lightly covered with scrub. West of Salt Point the shore runs northward into a long marshy bay, to the west of which again is a low Salt Point.

*Memorandum on the Portages and Streams and C.P.R. Reports, 1874. Sheet 11

unwooded point, from which bars of granite boulders extend southward into the lake.

Turning northward up the east side of the main portion of the lake, the shore is generally low, with a few small boulders lying on scattered broken fragments of limestone. The timber, chiefly burnt poplar, first touches the beach two miles north of this point. Some of the bays are shallow, while the points are built up of large boulders, with deep water off them. Four miles and a half north of the point fixed rock was seen for the first time since entering the lake. Four miles and a half further north a small island lies off the shore wooded with poplar, elm and willow, while the land to the east is wooded with poplar, elm and a few oak trees.

Rock exposure.

At Net Point there is another low exposure of bedded limestone; but the rest of the shore all the way to Point Brabant is low and more or less closely piled with a ridge of boulders.

Point Brabant.

At Point Brabant a limestone cliff extends for about a mile along the shore, rising at its highest point to about forty feet above the water. A long sloping gravel beach reaches from the foot of the almost vertical cliff to the edge of the water, and on this beach, and under the shelter of the cliff, a line of wide-spreading elms is growing. A similar row of trees may be seen in front of many of the other cliffs by this lake, indicating clearly that its waves are not at present cutting them, but that they were formed when the lake stood a few feet above its present level, when the ridge along the top of the Meadow Portage was also formed, and when consequently lakes Winnipegosis and Manitoba were joined into one great sheet of water which extended to the south and east over large areas in the province.

Old shore-cliff.

North of Point Brabant.

For five miles north from Point Brabant the shore is often protected by a sloping wall of boulders, behind which is a higher ridge of boulders wooded with elm. At the end of the above distance is a low cliff of limestone, north-east of which and a short distance back from the lake, is a hill of limestone rising by an easy slope from the edge of the water to a height of sixty feet, and strewn with dead birch, spruce and poplar. Its summit is slightly rolling parallel to the shore, and is covered with pebbles and rounded cobbles, while its western face is strewn with large masses, some possibly in place, of heavily-bedded dolomitic limestone.

Wade Point.

From this hill to Wade Point, a distance of seven miles, the shore is everywhere low, and generally bounded by a wall of Archæan boulders, and wooded with elms, behind which is a country clothed with poplar and some spruce. Gun Island is a mass of these boulders ten

feet in height, and is connected with the shore by a long bar of similar boulders, which stood a foot above the surface of the lake during the period of low water in 1889.

Change in character of shore.

North of Wade Point the character of the east shore changes considerably, and granite boulders, which form so prominent a feature of the beach to the south of it, are much less numerous, the boulder-strewn tract crossing the lake and continuing up the west side of Birch Island. The water to the south of Hunter's Island is everywhere shallow, and the shores slope very gradually into the lake. Boulders of gneiss are thickly scattered on the most southerly points. Elsewhere the beach is composed chiefly of more or less irregular fragments of limestone, which in most cases, as on the north side of Island Z, are probably derived from immediately underlying rock. North-east of Hunter's Island the beach is a belt, fifty to seventy-five yards in width, between the woods and the water, the upper part grass-grown, the lower part bare of vegetation, and scattered with debris, chiefly of moderately thin-bedded limestone with an occasional boulder of gneiss, all bedded in a soft light gray sandy clay.

Limestone hill.

In latitude 52° 23′ a hill of limestone, thirty-five feet in height, rises to the south of a shallow bay, and on its side sloping towards the lake is an old beach of rounded limestone gravel of the age of the Meadow Portage ridge.

Point Laronde.

From this hill northward to Point Laronde the shore is very monotonous, being everywhere very low, and composed of sandy clay irregularly strewn with fragments of limestone, and a few boulders of granite. The water off the shore is shallow, and stony bars project above its surface. The larger islands close to the shore are low, and wooded with spruce and poplar; their eastern sides are generally soft and marly, while their western sides are flat, like the main shore.

Hill Island.

Further out in the lake several wooded islands lie in the channel between Birch Island and the shore; the most conspicuous and interesting of these is Hill Island, the northern one of the group. It rises about forty feet above the water, and at its northern end, hidden among poplar and spruce trees, is a half-buried cliff of limestone, at the foot of this cliff is a terrace strewn with boulders down to fifteen feet above the water, below which the beach is composed of a sloping pavement of granite boulders from twelve to eighteen inches in diameter. On the east side of the island is another cliff, but it consists of compact glacial till, and a beach of large boulders extends from its foot down to the lake. On top of the cliff, at heights of twelve and twenty-five feet above the water, are deposits of rounded gravel, indicating old stages in the history of the lake.

Inland the island is generally thickly wooded with spruce, birch and poplar. From the north-east and north-west corners of the island gravel bars extend northward as reefs, and from the south end a gravel spit extends southward for 250 yards beyond the limit of the woods.

The other islands to the south are mostly low, with flat shores, and inland are generally wooded with poplar and a few spruce.

Low shore.

North of Point Laronde the east shore of the lake is everywhere low and flat, being often underlaid by thin-bedded limestone dipping gently towards the west, and running for a long distance under the water. This limestone has been very generally much broken by the shoving of the ice in spring, and the beach is therefore strewn with angular fragments of the rock. Two miles north of the point is the mouth of the only noticeable creek emptying into the east side of Lake Winnipegosis. It is fifty feet wide and from three to six inches deep, flows swiftly among boulders, and in the autumn of 1889 was falling about two feet over the beach into the lake. An Indian canoe route is said to go up this stream and across into a chain of lakes which connect with the northern end of Waterhen Lake, providing a short way to the Hudson's Bay Company's post on the latter lake, and one on which there is not much danger of detention by storms.

Canoe route.

Country east of the lake.

The country through which this route passes, and the whole of the region lying between Lakes Winnipegosis and Winnipeg, is described by Alexander Monroe, the Hudson's Bay Company's trader at Waterhen River, as a great flat-lying area, dotted with many small lakes, and traversed from south to north by a high ridge covered with Banksian pine, reaching as far as the Grand Rapids on the Saskatchewan.

Islands and points of boulders.

The islands off the shore are generally capped by a ridge of granite boulders, and the whole shore bears evidence of having been moulded to some extent by the ice of the glacial period, for the points run out into the lake parallel to the direction of the glacial striation, while behind them are shallow bays extending back into long, narrow marshes. On the low, flat beach are also many evidences of the shoving of the ice in spring. Boulders are lying on the soft clay, and grooves in which they have been pushed along extend from them towards the water. One large boulder of dark gray gneiss had a groove behind it seventy-four paces, at least, in length; thirty-four paces straight, then a bend and twenty paces straight, and then another bend and twenty more paces straight, to beneath the surface of the water.

Long Point.

At the north end of the bay east of Long Point, and again north of the bay to the west of the same point, a high wooded ridge rises back

from the shore, and the north shore of the lake follows the foot of this ridge in a moderately even line to the mouth of Swamp Creek. The shore of the latter bay is low and marshy, and a number of rills of dark brown water are flowing into its western side from a dense spruce swamp. The beach is of fine hard quartz sand, and is generally skirted with rushes.

Even shore

West of this bay, the beach for a short distance descends into shallow water, and then for more than thirty miles it maintains a very constant character. It is generally about 150 feet wide, with a gentle slope between the water and the edge of the woods, while the water, even close to the shore, is of considerable depth. The beach, which is probably the most beautiful anywhere on the lake, is partly overgrown with grass, and is composed of sandy clay, in which cobbles and pebbles of white limestone are embedded, many of them but little water-worn and showing well-marked glacial striæ. Large boulders of gneiss are comparatively rare.

Towards the eastern end of this part of the shore the gentle slope between the edge of the grass and the water shows many evidences of ice shoving, both in little heaps of gravel piled on the beach, and deep furrows ploughed in the mud.

Wooded shore

Behind the open shore is a forest of white and black poplar, mingled, in the distance, with birch and spruce. In this forest a hill rises by a gentle incline to a height of from sixty to ninety feet, and though its face is thickly overgrown with vegetation, some small boulders and cobbles, similar to those on the beach, can be seen lying on it here and there.

Old beaches and terraces.

While none of the older rocks are exposed in place on this shore, there are on the southern slope of the above-mentioned wooded ridge several terraces and ancient gravel beaches which are of considerable interest. The most conspicuous of these terraces extends along the face of the ridge at a height of from twenty to thirty feet above the water. One of the localities at which it is best shown is four miles south-east of the Western Mossy Portage. It is here scarped, and is seen to be composed almost exclusively of flattened, disc-shaped, water-worn pebbles of white limestone, with a few of dolomite, and a few others of granite, most of which still show traces of glacial striæ. The pebbles are embedded in a scanty matrix of white, slightly clayey sand. The summit of the terrace is twenty-seven feet above the lake and consists of three gravel ridges, all of about the same height, and all parallel to the shore, separated by narrow troughs, the trough behind the third ridge being ten feet deep, back of which the main hill rises with a gentle slope. These probably repre-

sent the remains of an ancient gravel spit which projected into the lake in the era of the Meadow Portage ridge, and the long gravel islands opposite this part of the shore, and now a mile and a quarter out in the lake, possibly also represent fragments of the same ancient spit.

Four miles west of the Eastern Mossy Portage, the woods have been burnt for a short distance, and two terraces are seen, one about the height of the last, and one very conspicuous, at a height of from fifty to sixty feet above the lake.

Eastern Mossy Portage.

The Eastern Mossy Portage, called by the Saulteux Indians *Kak-is-tĕt-i-nak*, The Man Ridge, starts from Lake Winnipegosis near the middle of this open stretch of shore line, and runs northward for a distance of about four miles to a shallow bay on the south side of Cedar Lake. It was first surveyed and levelled about the end of May, 1858, by Mr. A. W. Wells, acting as assistant to Mr. S. J. Dawson, who found that its total length was four miles and eighteen chains, and that Lake Winnipegosis was four feet higher than Cedar Lake, which was very low at the time.*

Surveys.

It was afterwards surveyed and levelled by Mr. Henry B. Smith, C.E., in 1873, and is described with a plan and section in his report as follows:—"The level of these lakes may be assumed to be equal. Starting from a fine open bay on Cedar Lake, with a bottom composed of mud and sand, sloping off gradually to a depth of six feet at a distance of 660 feet from the shore, the portage for three-quarters of a mile, passes over a corduroy road through a very soft muskeg or swamp, to a fine hard ridge of land, along which the Hudson's Bay Company have built their waggon road.

"The total length in a straight line between the lakes is nearly four miles. Travelling in a southerly direction from Cedar Lake the land rises gradually to a height of 93·14 feet at a point only one-quarter of a mile from the shore of Winnipegosis, then descends suddenly to its beach. Winnipegosis here presents a wide surface, affording no natural protection to boats from the heavy storms which are so frequent in these parts. The bottom of the lake, composed of limestone gravel, slopes away gradually to a depth of six feet at 200 feet from the shore."†

In the winter of 1880 Wm. Pearce, D.L.S., ran a survey line between the two lakes, crossing the portage a mile and a half from Lake

*Papers relative to the exploration of the country between Lake Superior and the Red River Settlement, London, Govt., 1859.

†Memorandum on the portages and streams, &c., by Henry B. Smith, C.E. C.P.R. Report, 1874, pp. 260-1.

Plan and Elevation of Mossy Portage between Cedar Lake and Lake Winnipegosis
from a survey by D. B. Dowling in 1897.

Winnipegosis; in September, 1889, it was examined by the writer, and lastly, in July, 1891, it was levelled by Mr. D. B. Dowling, who found the highest point on the trail ninety-three feet above Lake Winnipegosis, and this lake nine inches above Cedar Lake. The accompanying plan and elevation are from his surveys.

Description of Portage.

Starting from Lake Winnipegosis, the portage runs from the water over the beach-ridge, and immediately begins to ascend the hill, the top of which is reached on the third step at a height of ninety-three feet, where the ground is found to consist of water-worn discoidal limestone gravel. From this point it strikes northward along the top of a gravel ridge, which is at first wooded with spruce and then for a mile and a quarter with little else but Banksian pine, the land on either side being ten feet lower, and wooded with spruce and tamarack. The ridge throughout this distance is 100 to 200 feet wide, and consists of round or discoidal limestone gravel. It slopes lightly to the east, where in places there is a low subsidiary ridge, and as a rule descends somewhat more abruptly towards the west. In the woods to the east two other parallel and lower ridges were found, consisting of rounded limestone gravel, rising three or four feet above the surrounding country, and thickly wooded with spruce and poplar. The country is very wet, and covered with small spruce, tamarack and a few cedar, beneath which Indian tea (*Ledum latifolium*) and pitcher plant (*Sarracenia purpurea*) are growing in great abundance. In the above distance the portage ridge has declined from ninety-three to eighty-nine feet. It now drops slightly, and for the next quarter of a mile has an altitude of from eighty-two to eighty feet. Small spruce here begin to crowd in towards the trail from either side, Banksian pine becomes scarce, and some cedar trees are noticeable in the swamps both to the east and west. The ridge now has the general appearance of becoming more diffuse, but Mr. Dowling recognized branching gravel ridges at altitudes of sixty and seventy feet, the latter extending as a gravel spit into the angle of the former, which is at the same level as the high terrace along the north shore of Lake Winnipegosis. North of this gravel ridge, which is two miles and a third from the shore of the last named lake, the road still continues along a belt of land somewhat higher than the surrounding country, and boulders of gneiss and limestone, chiefly the former, begin to appear. At a distance of two-thirds of a mile from Cedar Lake the ridge disappears altogether, at a height of thirty feet above the lake, and the road enters a wet swamp wooded with spruce, tamarack and cedar, across which the Hudson's Bay Company built a corduroy road of small poles, over which goods were conveyed in a waggon from lake to lake.

Gravel ridges.

Descent towards Cedar Lake.

North end.

The north end of the portage opens on the shore of Cedar Lake, rising over a ridge of light red sand with a crest six feet above the water. The bay appears to be everywhere shallow, and a small lightly-wooded island of boulders lies across its mouth.

Ancient lake beaches.

As will be seen from the above description, and the accompanying plan and elevation, the line of the portage road is along and across several ancient beaches, formed on an original ridge in the underlying till when the lake was at some of its higher stages. The top of the portage would represent the crest of an island, formed at a period when the lake was ninety-three feet above its present level, or 921 feet above the level of the sea. From this stage the water gradually declined, forming, while it was falling, two or three small beach-lines, till it reached a height of sixty feet above Winnipegosis, or 888 feet above the sea, when a strong ridge was formed, well shown both north and south of the higher portions of the portage, as well as in other places, showing that the lake stood at this level for a considerable period. From this latter level the water fell rapidly to a height of from twenty to thirty feet above Lake Winnipegosis, or about 850 feet above the sea, so that no beaches were formed on the portage ridge between these two elevations; but at the latter, a gravel ridge extends along the face of the hill on the south side of the portage, while towards its north end the country, at about the same elevation, descends into a cedar swamp which slopes toward Cedar Lake.

Later history of the lake.

This portage, therefore, furnishes a very interesting and concise history of Lake Winnipegosis in several of its later stages.

Western Mossy Portage.

The Western Mossy Portage, called by the Indians *Muskegónigá* or the Mossy Portage, is used chiefly in winter by the Indians with dog trains. A paced survey was made of it by Mr. Dowling in 1889, and altitudes were determined by two aneroids. It starts from the open shore of Lake Winnipegosis, opposite Shannon Island, and ascends rapidly through woods of white and black poplar to a height of sixty feet, and then by a much more gentle incline through spruce and poplar to a total height of seventy-five feet at a distance of three-quarters of a mile from the lake. From here it slopes gently through a mossy swamp to the south-west angle of Cedar Lake near the mouth of a small creek; the fore part of the distance being thickly wooded with small spruce, and the latter part with scattered tamarack.

The total length of the portage is about four miles and a quarter.

Depth of water.

In Lake Winnipegosis a depth of eighteen feet can be obtained a short distance from the shore, while in Cedar Lake the water is so shallow for a long distance from the end of the portage that it is difficult to get to the land with a light canoe.

Swamp Creek empties into the lake at the edge of a very extensive marsh, and south of this marsh a forest of spruce and poplar stands close to the shore, skirted by a narrow belt of grass growing on sand, pebbles and boulders. In front of this is a bare strip of sand and pebbles fifty feet in width, which shows many evidences of ice-shoving in troughs cut in the sand, and pebbles shoved back into little mounds. Swamp Creek

All the way to the mouth of Overflowing River the shore is flat and uninteresting, the water off it being in places so shallow that it is difficult for a canoe drawing six inches to get within a quarter of a mile of land. It consists of a soft clayey sand, in which are imbedded, so as to completely cover the sand, pebbles of gneiss and fragments of limestone and dolomite. Behind this flat shore is a ridge of boulders of gneiss and limestone, raised to about the general level of the surrounding country, which, except at the prominent points, is wooded to within a short distance of the water.

Overflowing River is a small stream said to rise in Leaf Lake, just on the western side of the map. It flows first north-eastward and then south-eastward to its mouth at the north-western extremity of Lake Winnipegosis. Here it is 200 feet wide, with brownish water, in which, in September, 1889, there was no perceptible current. The shore adjoining it is low, with an open saline flat covered with grass and the red salt plant (*Salicornia herbacea*) to the north, and a forest of poplar and spruce to the south. Three-quarters of a mile up the river, the bank is abrupt and twelve feet in height, and a rapid is encountered with a fall of about three feet, where the water flows over a bed of boulders of gneiss and broken fragments of hard compact limestone. At the above date it was almost dry, but in August, 1888, Mr. Dowling ascended the stream with two large canoes for a distance of thirty-seven miles. He gives the following description of its characters:— Overflowing River.

"At the first rapid a cut-bank on the south-east side shows six feet of stratified sand and gravel; at the next bend the bank is twelve feet high, and is composed of light gray clay, with a few striated pebbles; while at the end of two miles the banks have risen to a height of twenty feet. In this distance there are eight rapids of varying length, the uppermost and largest one having a fall of more than four feet, and they all seem to be caused by accumulations of boulders washed from the clay of the banks. Throughout this distance the timber on both sides of the stream is mostly fire-killed. Rapids.

"Above the eighth rapid the river turns slightly more to the westward, still flowing through burnt country. The banks descend to an average height of about eight feet. The stream, though crooked, is deep,

and for six miles has a uniform current of about one mile an hour, and then, with a slight bend for a mile towards the north-west, it falls in the above distance down three small rapids. At the upper one of the series a dark yellow limestone was recognized in the bed of the stream.

"The next westerly bend opens to the view a fine straight stretch of river at least a mile in length, with a mean width of 300 feet, and apparently very deep. On either side is a narrow fringe of spruce and tamarack, behind which is a tamarack swamp.

Swamp and poplar forest.

"Above this straight portion of its course the river flows through a narrow strip of poplar woods, and then, coming from the northward for a distance of six miles, it winds in a very tortuous channel of twice the above length through a belt of mossy bog, which extends towards the north-east and south-west, and has an approximate width of three miles in a south-easterly and north-westerly direction. Ash, elm, poplar and willow occasionally overhang the stream.

Tributaries.

"Two small tributaries join the Overflowing River in this part of its course, one coming from the south-west through the middle of the bog, and the other from the north-east, draining a lake which can be seen from the extreme north-easterly bend of the river, and the shores of which appeared to be generally low and marshy.

"The river now turns sharply to the west, and for seven miles maintains the same tortuous character, but towards the end of this distance a current becomes appreciable, and the points of land included in the bends gradually become thickly wooded, till at last it leaves the bog and again enters the forest, when the banks suddenly rise to a height of at least twenty feet, and descend in a gravel-covered slope to the water. Above this the river was ascended for two miles, but was found to be very shallow, and to have a strong current with a succession of small rapids, in which there was hardly enough water to float an empty canoe. The surrounding forest consists of large poplar, mixed with birch and some spruce of moderate size."

Higher gravel banks and strong current

From the mouth of Overflowing River southward and eastward to Macoun Point the shore is for the most part grassy, sloping gently to the water, and in places fringed with rushes. Just within the edge of the woods a ridge, apparently composed of gravel, runs parallel with the beach. About the middle of the distance, or six miles from the mouth of the river, a long bare diffuse point extends into the lake. It is composed chiefly of sand and limestone gravel, but the end, which is a little higher than the rest, is piled round with Archæan boulders.

Macoun Point.

Macoun Point is wooded with a beautiful grove of large elms. Around the grove is a beach of rounded limestone gravel, and in front

of and a little below this beach is a line of boulders of gneiss and limestone, some of which show glacial striæ From the foot of this line of boulders the shore extends with a very gentle slope to the edge of the water, and is strewn with angular fragments of porous dolomite broken from the parent rock beneath, and shoved over it by flow ice. The rock here seen in place is the first met with on the shore since leaving Ami Island at the north-east corner of the lake.

From Macoun Point southward to the mouth of Red Deer River the shore is very irregular, and the more prominent headlands are formed of cliffs of light gray limestone. The shores of the bays are low and composed of clayey sand or broken pebbles, and are commonly margined with rushes. At the bottom of the deepest bay is a bare saline area around some salt springs, and this again is surrounded by the usual growth of thin wiry grass. These salt springs are the most northern that were observed on the west side of the lake. Dawson Bay.

Red Deer River flows into the west side of Dawson Bay just north of a small club-shaped peninsula, terminating in a low wooded point underlain by white dolomitic limestone. The channel at its mouth is from three to twelve feet deep, not being obstructed by bars of sand or gravel. It has a width of from 200 to 300 feet, and banks three feet high, behind which, on the north side, is a meadow covered with rich grasses and vetches. Back of this is a forest of poplar and spruce, which shows many traces of the ravages of fire. Red Deer River.

From the mouth of Red Deer River to Whiteaves Point the shore is very irregular. In many places it consists of cliffs of Devonian limestone which have been formed when the lake was at the stage of the Meadow Portage ridge, and are now in many cases behind narrow belts of timber. These will be found more fully described on subsequent pages.

Seven miles south of Red Deer River is a shallow bay, almost cut off from the rest of the lake by a long straight spit of rounded gravel shaded by a line of spreading elm trees; and at the bottom of the bay is the mouth of Steep Rock River. This river is said to rise in two lakes on the summit of Porcupine Mountain, and to flow down its face in a gorge that can be clearly seen from the islands in Dawson Bay. On reaching the level country it opens into a marshy lake, or wide marsh, surrounded by tall spruce and covered with cat-tail and other rushes. Through this marsh it winds with ill-defined banks, and then appears to flow from its south-east end as a shallow stony stream. In ascending or descending this river with canoes the Indians make use of a good portage path 1,650 paces in length, cut out through a forest of spruce and poplar on the north side of the river, from the Steep Rock River.

marsh to the lower end of the rapids. The river at the latter point is forty feet wide and eight inches deep, flowing with a swift current over stones and little gravel bars, and the water appears to be slightly saline. For the rest of the way to the lake it has little or no current, and the banks are wooded for a short distance, and then are low, marshy, and skirted with willows.

Bell River.

Five miles and a half south-east of the mouth of Steep Rock River, Bell River flows into the bottom of another shallow bay. This river rises on the summit of Porcupine Mountain, and flowing eastward in the bottom of a gorge in the face of the mountain turns northward and empties into the south-west corner of Dawson Bay. Its upper course is described on a subsequent page, but at its mouth it is thirty feet wide and eighteen inches deep, with a bed obstructed by large boulders of Archæan gneiss, large and small irregular fragments of Devonian limestone and a few of white Dakota sandstone.

Islands.

The islands in Dawson Bay are all well wooded, and most of them are immediately underlaid by white limestone, which often projects from among the trees in bold vertical cliffs.

Professor Macoun's description.

Prof. Macoun, who visited this lake in 1881, speaks of this portion of it as follows :* –

"The northern end of Lake Winnipegosis is filled with lovely islands, which are margined with fine drooping elms of a large size. The sail across Dawson Bay on a lovely day in July reveals more natural beauties than I ever before beheld on our inland waters. Green islands, with white sand or gravel beaches, covered with drooping elms and other fine trees, the mainland rising gradually up from the water covered with an unbroken front of tall poplars intermixing with the gloomy spruce, deep bays backed with the distant forest, and high over all the steep escarpment of Porcupine Mountain, form a picture, as seen from the lake, which has few equals in any part of the world. Point Wilkins, a bold promontory pushing out into the bay, and rising almost perpendicularly to a height of seventy (83) feet, is a prominent and beautiful object. Crossing a bay to the north of this, and rounding a low point, we entered the mouth of Red Deer River and, after ascending it a mile or more, camped at a salt spring, where the swift water commences."

Whiteaves Point

On the east side of Dawson Bay, at Whiteaves Point, a cliff of highly fossiliferous limestone rises to a height of thirty feet above the water, but is now hidden by a belt of elms fifty feet in width at the back of the gravel beach. Off the point is a small horse-shoe shaped island,

* Report of Explorations by Professor John Macoun, M.A., F.L.S. Ann. Rept. Dept. of Interior, 1881, p. 75. Ottawa, Govt., 1882.

composed of rounded pebbles of limestone, at which boats bound down the lake usually stop to take on ballast.

North of Whiteaves Point is a wide bay, in which lie several islands wooded with elm, poplar and willow. The outermost island is a high limestone rock facing the west in white vertical or overhanging cliffs, and diminishing towards the south to a gravel spit. Those of the group at the bottom of the bay are mostly low, and composed of pebbles and irregular masses of white dolomitic limestone mingled with boulders of gneiss.

The shore opposite these islands is generally low, but rises gradually to a height of twenty-five feet within woods of large spruce and poplar, under which is a close thicket of spicated maple (*A. spicatum*). Northward to Nason Point the country, though low, continues thickly wooded, and from the edge of the woods a narrow grassy belt slopes gradually to the deep water. At the points, the beach is flat, and scattered with fragments of limestone. Nason Point.

From Nason Point, across the north end of the peninsula east of Dawson Bay, to Channel Island, the country is wooded with spruce and poplar, and between the woods and the water is a narrow, flat-lying belt of grassy and stony land. Over this the ice shoves in spring back to a ridge of large and small irregular fragments of rock. At one point, on the south-west side of Cameron Bay, a cliff of limestone thirty-seven feet high, peeping out from behind a narrow belt of small poplars, breaks the general monotony of the low-lying shore.

Many low islands lie in the channel north of this peninsula, all with flat-lying shores, occasionally strewn with a few boulders. No cliffs of rock are anywhere to be seen. All are wooded with belts of timber, usually spruce and poplar. Of these, the largest is Spruce Island, and next to it in size is Channel Island, which is almost joined to the shore by a narrow neck of meadow land, across the north end of which is a channel fifty feet wide much obstructed by boulders of gneiss. It is at times difficult to take a canoe through this channel, for in some seasons a depth of but a few inches of water can be found in it. Low islands.

Shannon Island is also low and wooded, but a group of three small islands lying midway between this and Channel Island is of somewhat greater interest than the rest. They consist of bars of gravel, forming crests along the summit of reefs or low-lying islands of boulder-clay, and clearly illustrate the combined action of water and ice in forming the present shore features of the lake. The middle island, which is probably the most conspicuous, is a long, crescentic bar of Three islands of gravel.

water-worn limestone pebbles, very free from any mixture of clayey material. It is a mile long, 120 feet wide, and twelve feet high in the middle, where it supports a few willows and stunted elms. To the east the water is shallow for a very short distance, and then descends to a considerable depth, while to the west the shallow water extends for a comparatively long distance, leaving the bar along the eastern side of the shoal. Gneissoid boulders are scattered at the foot of the bar, and in this shallow water, especially at the north end of the island and in the immediate vicinity, a little quartz sand may also be seen in a couple of places near the water's edge.

Towards its north end the bar declines gradually to the edge of the water, and continues just beneath its surface to the point of a similar but smaller gravel island to the north.

The most southern of the three islands is divided from the middle one by a narrow strait of moderately deep water, and its northern point is composed, at the water's edge, of irregular, broken fragments of limestone with a few boulders of gneiss. The north-eastern side of the island is a gently curved bar of limestone gravel, wooded with elm and poplar, while to the south-west of this bar is a low flat, but little above the water, covered with irregular fragments of limestone and scantily overgrown with grass.

Mode of formation.

The mode of formation of the gravel bars is apparent from a consideration of the above-described characters. We have seen that the spring ice everywhere scrapes the low-lying shores of the lake, and shoves the collected debris before it into a ridge, which is often almost out of the reach of the water, the pebbles in which are therefore but slightly rounded, and are mixed with much clay and sand. In this part of the lake there have originally been islands of till or stony clay rising to about the level of the water, the southern one being still above the low water stage. The shoving of the ice in spring, out of Dawson Bay into the body of the lake, scrapes the surface of the low stony islands, and carries the collected material to their eastern side. Here the waves from the open lake beat against it, wash out the fine material, and pile the now rounded and assorted pebbles into an even ridge.

Pelican Bay.

East of Channel Island, Pelican Bay, a long shallow arm of the lake, extends southward for a distance of twenty-five miles, and its shores being low, and but little affected by waves and currents, show many beautiful examples of the influence of ice.

For sixteen miles down the west side of the bay the shore is low, with a width of from fifty to two hundred yards of bare marly flats between the water and the spruce and poplar forest. On this flat

J. B. Tyrrell, Photo., July 20, 1889.

Ice-shoved Boulder with curved Groove, showing its track from out in the Water, with the small Stones pushed in front of it.

PELICAN BAY, LAKE WINNIPEGOSIS.

are lying boulders of gneiss and fragments of Silurian and Devonian limestone. At one point there is a boulder of Devonian limestone nine feet long, eight feet wide and six feet high, with smoothed and well glaciated sides and corners, lying one hundred feet from the water. It has recently been moved at least ten feet, as a groove of this length runs out from it towards the water, while on its opposite side boulders and small stones are piled against it to half its height. Glaciated boulder

At the end of the sixteen miles a hill of limestone rises to a height of twenty-six feet and a half behind a skirting of small poplar and birch. The surface of the limestone has been smoothly glaciated, but has been so much corroded by vegetation that I was unable to detect any striæ. Limestone hill.

Five miles south-east of the limestone hill, and at the second Narrows in the Bay, a point projects from the low shore. It is essentially composed of sandy clay scattered over with irregular angular fragments of limestone, with which are mingled a few nodules of chert and iron pyrites. In a few places on the bar is some small rounded gravel.

The bar is broken by several hollows, in which many large boulders of gneiss are lying. Some of them, especially those lying on higher ground, show clear evidence of having been shoved up by the ice. A large one, 5 ft. x 4 ft. 10 in. x 4 ft. has a groove fifty-six feet long running down from it in a direction S. 80° E., while on its opposite side is a pile of gravel and small boulders. The groove is in places eighteen inches deep, with clay and small stones piled up as a ridge on each side. Ice-grooved shore.

Also near the base of the bar is a large transported boulder of dark gray biotite granite, of the typical glacial shape, with smooth, even or slightly grooved sides and rough ends. It has a greatest length of nineteen feet three inches, a greatest width of nine feet five inches, and a height above the ground of six feet eight inches.

Two miles south of this bar, and a quarter of a mile back from the shore, among woods of small spruce, is a considerable tract of arid land covered with a crust of salt, from which the almost dry channel of a small saline brook descends to the lake. Salt spring

This the third, or most southern division of Pelican Bay, is everywhere very shallow, and boulders are projecting out of the water at a distance of from a quarter to half a mile from the shore, which consists of mud flats, thickly scattered over with fragments of white limestone and grooved by lake ice. Back from the lake there is a large amount of good spruce.

Pelican Creek, a shallow stream, about forty feet wide, empties into the south-west angle of the bay. It is said to flow from a lake a short Pelican Creek.

distance in the interior, known as Pelican Lake. In July, 1889, the creek was ascended in a canoe for a quarter of a mile to a stony rapid, where there was only a little water trickling among the stones. On the east side of the mouth of the creek, and a third of a mile back from the bay, is a bare hill about thirty feet high surrounded by groves of small spruce and poplar. Its face is scattered with large boulders, while on its summit, which extends as a ridge in a direction N. 75° E., are several springs of brine described on a succeeding page. This ridge is a quarter of a mile long, and slopes to the south in a narrow opening through the woods to a wide arid plain. The subsoil appears to consist of broken fragments of white limestone.

Salt springs.

Returning northward down the east side of Pelican Bay the water in the southern division is so shallow that it is practically impossible to reach the land with a large canoe, and in the second or middle division the water is also very shallow, the bottom of soft sandy clay scattered with fragments of limestone and a few nodules of iron pyrites. Many of the former have one smooth side covered with glacial striæ, and are evidently derived from the till. In this protected bay, and especially on its north side, which is bordered by a fringe of rushes, are some of the best examples of ice-grooving that have ever come under the writer's observation. Boulders are lying here and there, and most of them show signs of having been moved from three inches up to thirty-three paces. The sand and pebbles of the beach are generally piled up on their landward side, while a groove extends towards the lake. The majority of the shorter grooves on the north shore trend N. 60° to 75° W. One, ten paces long, trends N. 10° W., and in this the boulder is seen to have at first lain transversely to the direction of the groove, and to have been turned round and shoved with its greater axis along the groove. A group of six boulders have been shoved in a direction S. 70° W. Another boulder 44 x 45 x 22 inches has taken the following course, turning sharply at the changes of direction: From its starting place in the water N. 50° W. for fourteen feet six inches, then N. 10° W. thirty-seven feet, then N. 40° W. thirteen feet six inches, then N. 25° W. ten feet eight inches to the stone. Another boulder is now lying in the water at the end of a straight groove about fifty feet long, running from it in a direction N. 35° W. towards the shore, and pebbles are piled up on its lakeward side, showing that it has been shoved out from the shore when the ice was carried out by the wind. The shore throughout this distance has a constant direction S. 50° W.

Ice-shoved boulders.

The irregularity in length and direction of these grooves on a soft, straight shore shows clearly that they are caused by the irregular

J. B. Tyrrell, Photo., July 20, 1889.

Ice-shoved Boulder, and Groove behind it 30 feet long, showing its track up the gently sloping beach.

PELICAN BAY, LAKE WINNIPEGOSIS.

pressure of broken ice in the spring, rather than by the regular expansion of the ice during the winter with the variations of the temperature.

Behind this low beach is a wall of boulders that have been shoved back against the higher ground within the edge of the woods, and have reached their permanent resting place, where they can no longer be affected to any considerable extent by the waves and ice of the present lake. Within the woods is a ridge twenty feet high scattered with gneissoid boulders. Ridge of boulders.

In the mouth of Pelican Bay are a number of low but beautifully wooded islands, with shores of clay and boulders running out into spits of limestone gravel.

From Whiskey Jack Point, which lies at the eastern side of the entrance to the bay, the shore turns towards the south-east, and for five miles is composed of water-worn gravel along the face of a forest of spruce and poplar. Within the forest a ridge rises to a height of twenty-five feet above the water, and its summit is strewn with large boulders of gneiss. In summer the trees close to the beach are everywhere wound with the webs of innumerable spiders, set to entrap the swarms of waterflies bred in the lake. Whiskey Jack Point

For another five miles, to Devil's Point, the shore is low and sloping, and composed of clay scattered over with fragments of white limestone with very few boulders, behind which is an ice-shoved ridge of irregular gravel.

Devil's Point is a relatively high, rounded promontory, extending northward towards Grand Island, from an elevated portion of the mainland. On its western side rock appears in place at the water's edge, while in other places the beach is piled to a height of sixteen feet with rounded masses of rock, over which is a grove of birch and poplar. Behind this grove is a cliff of limestone thirteen feet high, and above the cliff the land inclines gently upwards to a total height of forty-five feet. Along the western face of this slope a few large boulders of gneiss are lying, and its crest is composed of more or less rounded pebbles and cobbles of limestone. Devil's Point.

Grand Island, to the north of this point, has a general wedge-like shape, with a greatest length of five miles and a quarter and a greatest breadth of two miles. It is thickly timbered throughout, and while its northern and eastern sides slope gradually to the water, its western side rises in a cliff to a height of fifty feet, on the top of which is a gravel ridge with a total height of fifty-five feet above the lake. This evidently represents a portion of the same shore line that has already been seen at Devil's Point and on Mossy Portage, having Grand Island.

here formed the crest or point of an island standing out in the middle of Lake Agassiz.

Cormorant Islands

East of Grand Island lie the Cormorant Islands, the largest of which is wooded, while the others are bare, stony bars, on which great numbers of cormorants and pelicans annually rear their young. They consist of boulders of gneiss and limestone and nodules of iron pyrites.

From Devil's Point the shore turns southward for eighty-five miles, forming the western side of the main portion of Lake Winnipegosis. For the first ten miles the beach is low and muddy, with a ridge of boulders or fragments of limestone back from the water along the edge of a tract of low-lying land covered with small burnt timber. Near a point at the south end of this distance a ridge twenty-eight feet high, covered with burnt and partly fallen spruce and poplar, runs east and west behind the low beach, and consists on the surface of large and small rounded or partly rounded water-worn fragments of limestone with a few boulders of gneiss.

Hill on shore.

Between this hill and Fox Point is a bay surrounded by low shores wooded with fire-killed poplar and small spruce. In the mouth of the bay is a wooded island, between which and the latter point the lake has a depth of from fourteen to seventeen feet.

Pemican Island

Six miles and a half north of Fox Point Pemican Island rises from the lake at a distance of more than two miles from shore. It has a greatest length of about three-quarters of a mile, and consists of a wooded limestone hill rising to a height of forty feet above the lake. On its northern side it is surrounded by a beach of closely-packed boulders of gneiss, while to the south and east the shore is flat, and behind it, within a belt of elm and maple, is a cliff of limestone. Towards the south-west the island is terminated by a long, naked spit of limestone gravel rising three feet above the water. The occurrence of fragments of lignite on this bar and on the adjoining beach has long been known to the Indians, and they assert that it is washed up out of the lake by every storm. It is doubtless derived from an outlier of Cretaceous sands or shales lying just beneath the surface of the water on the south side of this island.

North Manitou Island.

North Manitou Island lies four miles south-east of Fox Point, and the water throughout the distance between them has a general depth of from twenty-four to twenty-six feet, with a muddy bottom. The island has once been wooded with very large spruce, birch, poplar and elm, but most of the trees are dead and falling. The shore on its north side is a narrow belt of limestone fragments, stretching to the water from the foot of an ancient low cliff, now sloping and covered with vegetation. At the north-east point

there is a steep wall of closely piled boulders ten feet in height. The east side is a narrow beach of limestone gravel, while the west side is muddy, and slopes off into shallow water. From the south point a spit of limestone gravel extends southward for a third of a mile, and from its termination a narrow, shallow bar extends a long distance towards Birch Island.

Birch Island. Birch Island is a large land area lying in the middle of Lake Winnipegosis, and approaching to within a short distance of both its eastern and western shores, thus dividing it more or less completely into two parts. It has a greatest length of seventeen miles, a greatest breadth of five miles and a total area of seventy-four square miles. It has formerly been well timbered, but as far as can be determined from the shore, the timber has all been destroyed by fire, and none of any value remains.

At Roderick Point, on its north shore, low cliffs of limestone rise above the gravel beach. The remaining shores are generally low, the west and south sides being thickly strewn with boulders of gneiss, with long stony points occasionally running out towards the south.

"Drumlins." West of Birch Island a number of small islands lie in and obstruct the channel. They are all composed more or less entirely of boulders, and are elongated in the direction in which the Manitoban lobe of the Laurentide glacier has moved across this whole area, being of the nature of Drumlins or raised ridges of till. As a rule, a belt of elm and poplar is growing along their crests.

Camping Islands. From Birch Island to Duck Bay the west side of the lake is generally low, and often has a beach of gravel with boulder points. Off Duck Bay the Camping Islands are very similar to those already described lying west of Birch Island, and consist essentially of ridges of boulders lying parallel to the direction of glaciation. The ridges rise in places to heights of twelve feet above the lake, and they are often worn down by the waves into bars of rounded gravel. Their crests are wooded with small groves of poplar, spruce, elm and ash-leaved maple.

Duck Bay. Duck Bay is little more than a westward continuation of this group of islands. It consists of several shallow lakes connected by narrow arms, which run out towards the north and south into extensive marshes. Through one of these marshes the South Duck River flows for a considerable distance in a well-defined channel 100 feet wide before it empties into the "bay," while the North Duck River joins the most westerly portion of the open water as a brook with dry grassy banks. A short distance above its mouth, near where it emerges from the spruce forest, it is fifty feet wide and three feet deep, with a slight current.

The point south of the entrance to Duck Bay is a bar of boulders 150 yards in length piled regularly to a height of eight feet above the water. A gently rounding bay stretches southward from this point, the shore of which is chiefly composed of pebbles of limestone with a few boulders of gneiss. Near the bottom of this bay, seventy yards back from the lake, an old abandoned trading post of the Hudson's Bay Company is very prettily situated in poplar woods.

Old trading post.

From Duck Bay southward to Pine River, a distance of about eleven miles, the beach is composed of sand or gravel, behind which is a wall of boulders, and the salient points are also entirely surrounded by boulders. On the ridge thus formed a row of poplar and ash is growing, behind which a low meadow extends for a short distance to a forest.

Pine River.

Pine River, for a mile and a half up from its mouth, is about one hundred feet wide and from three to five feet deep, with dark, brackish water, without perceptible current. The banks are low and mostly grassy, and back of them are forests of poplar and spruce. At the head of this navigable stretch is a rapid down which the river flows through an accumulation of large boulders of gneiss, and a short distance below this rapid the Hudson's Bay Company have a trading store on the west bank, which was built in the autumn of 1887, when the store at Duck Bay was abandoned. Below this store, but on the east bank, the Roman Catholics have a church and mission school. On the west bank of the river half a mile above its mouth, is a bare, salty plain, in the middle of which are several springs of brine. The springs are surrounded by broken masses of limestone and boulders of gneiss, while the ground generally is a soft, springy mud.

Sagemace Bay.

From Pine River, Sagemace Bay stretches southward for twenty-five miles, and is separated from the main body of the lake by the point of land known as Red Deer Peninsula. Its shores and islands are everywhere low, and without any signs of the underlying limestone. The beach on its eastern side is composed chiefly of boulders from four to eighteen inches in diameter, with a few limestone pebbles, except in two or three of the most sheltered bays, where short, sandy beaches are found. In some places the larger boulders, which are mostly of gneiss, are piled in an evenly sloping wall, but in the majority of places the smaller boulders of gneiss and limestone are scattered on a slight incline down to the lake, while the larger ones lie near the roots of the trees at the level of the highest stages of the water. Off the shore the water is generally moderately deep and free from weeds. The southern and western sides of the bay are shallow, and, except at the points, are fringed with narrow bands of rushes. The beach is a ridge of small

gravel, with boulders along its crest, and is covered with grass, deciduous plants and small berry bushes. Poplar, oak and willow form small groves all along the shore.

The islands are all very similar in character. The interiors are wooded, the larger ones with spruce as well as poplar. The shores are composed of sand and boulders, and are occasionally fringed with rushes in the more sheltered places.

Red Deer Point.

Red Deer Point is surrounded by a wall of boulders of gneiss and limestone and the low island to the north of it is simply a boulder reef.

From this point southward to the mouth of Mossy River, a distance of twenty-nine miles, the shore is very irregular, being broken by narrow bays and long gravel or boulder points. Low cliffs of limestone occasionally overhang the lake in the first half of the distance, but most of the salient points throughout are composed of boulders. The bays have beaches of more or less rounded gravel, in front of which a sloping boulder pavement sometimes stretches to the water.

Monkman's salt springs.

At a point six miles north of Mossy River the straight beach is composed of small boulders and pebbles of gneiss and limestone. A hundred feet back from the water the shore rises in a low ridge of rounded gravel wooded with a few small willows. Behind this ridge a grassy prairie stretches westward for a quarter of a mile, to several springs of brine, rising in the distance about eight feet. To the north it is bounded by a grove of poplar and small oak, while to the south the poplar is mixed with spruce. On an arid, salty plain to the west are the ruins of several old houses where Monkman and others used to live when they supplied the Red River colony with salt, and the remains of iron pans in which the brine was boiled down. These salt springs will be treated of more fully on a subsequent page.

South shore of lake.

From the mouth of Mossy River eastward to Meadow Portage, a distance of thirteen miles, the south shore of the lake is everywhere low, and surrounded by a naked wall of boulders; while in the rounded bays between the points the beach is occasionally a closely-packed boulder pavement sloping up at an angle of about 15° to a wave-formed gravel ridge, or in other places boulders are more thinly and irregularly scattered in front of this ridge. On the ridge itself there is usually a narrow belt of maple, elm, ash and oak, while behind it a low-lying marsh stretches back to the poplar forest.

LAKE DAUPHIN.

Position and extent.

Lake Dauphin lies in the midst of an alluvial plain about nine miles south of Lake Winnipegosis, into which it is discharged by the Mossy

River. It has a greatest length of twenty-six miles, a greatest breadth of eleven miles, a shore line of sixty-four miles, and an area of one hundred and ninety-six square miles. Its greatest ascertained depth is twelve feet and its approximative elevation, deduced from barometric readings and the estimated fall of Mossy River, is eight hundred and sixty feet above the sea.

History.

Its name is associated with the earliest explorations in the North-west, since Fort Dauphin, one of the trading establishments of the French before the cession of Canada to Great Britain, appears to have been situated on its shore, and probably near its north-western extremity. This fort was founded in the autumn of 1741 by Pierre, one of the sons of Sieur de la Verendrye, who travelled northward from Fort la Reine (Portage la Prairie) across Prairie Portage into Lake Manitoba, and thence probably by the old canoe route to Lake Dauphin*.

Ruins of old forts.

At the present time ruins of old trading posts of the Hudson's Bay Company can be seen on the west side of the lake, eight miles south of the mouth of Valley River, and at the edge of the forest at the south-east angle of the lake.

Low shores.

The shores of the lake are everywhere low, and show no exposures of the underlying Palæozoic rocks. The projecting points, except those formed by the tributary streams, are composed entirely of boulders, which on the south side run out as comparatively long, narrow arms into the water, while on the east side they are merely gently-rounded prominences. Between the points the west and south shores are very low, and are surrounded by a sand and gravel beach, extending back into a marsh. The east shore often presents to the lake a regularly built embankment of boulders or cobble-stones, behind which there is occasionally a low cliff of light gray till with boulders. Elm, ash, oak and maple are growing on top of the beach, and in the background is often an open forest of poplar.

Five small streams empty into the south and west sides of the lake, most of which rise on the summit or eastern face of the Riding Mountain and flow across the rich alluvial plain between the mountain and lake.

*P. Margry. Mémoires et Documents, &c. Vol. 6, pp. 591, 594 and 617. Bougainville states that "80 lieues from La Reine (the fort) is situated on the River Minanghenachequeké or de l'eau trouble" evidently Mossy River, as the name given me by the Indians for this stream was Minâkweniskegow, which is clearly the same word. P. Margry. Vol. 4.

Peter Pond, who appears to have been the first Englishman to occupy this fort after it was abandoned by the French, gives the location of the post occupied by him in 1775 at the north-west angle of the lake. P. Pond's Map of 1785. Can. Arch., 1889, p. 53.

For other references to this post see "Henry's Travels," p. 260. "Harmon's Journal," p. 52. Alex. Mackenzie's History of the Fur Trade. Alex. Henry Ms. in Parliamentary Library.

Turtle River is the most southern of these five streams. It is stated to [illegible] on the eastern face of the mountain and in some extensive marshes on the plain to the east. At the crossing of the cart trail to Lake Manitoba, the creek, in October, 1889, was twenty feet wide in a winding channel twelve feet deep. The bottom was stony, and the banks were wooded with poplar, elm and willow. Here a thriving Métis settlement has been established within the last few years. From this point to the lake the adjoining country is generally a level, grassy plain, and at its mouth the river is fifty feet wide and from two to four feet deep, emptying into the lake over a shallow sand bar. Turtle River.

The trail mentioned above runs for about seven miles through undulating country dotted with poplar groves, at first ascending a gradual slope scattered with boulders of gneiss, &c. It then enters the poplar forest, through which it is cut eastward to Ebb and Flow Lake. The surface continues generally undulating, and appears to be underlaid directly by light gray till. In range 13 the trail reaches a small ridge of rounded gravel five feet high and 250 feet wide, along which the old trail followed by Prof. H. Y. Hind in 1858 is stated to run for several miles, and which here joins the trail now used. The ridge comes from the north-west, and a quarter of a mile to the south-east it ends in a rounded point, beyond which is a level, grassy plain. The elevation of this ridge, as determined by several aneroid readings, is 933 feet above the sea. From this ridge, on which we had camped for the night, the trail runs for about 150 yards on an ill defined ridge trending north-east, and then turns eastward on an open, narrow, well-rounded ridge of small gravel, on the south side of which is a meadow, while to the north is a lower country wooded with spruce and tamarack. The face of this ridge or old beach is thickly scattered with boulders; it soon turns to the north and may continue for a long distance, but the trail leaves it and descends into the woods. Near the eastern side of range 13 the trail crosses another well-defined ridge, consisting of sand and small rounded pebbles of limestone. It runs N. 50° W. and S. 50° E., is four feet high and 150 feet wide, and has an approximate elevation of 910 feet above the sea. Manitoba House trail. Old trail. [illegible].

From this ridge the trail runs north-eastward for two miles and then turns south-east and runs for a mile or more along the face of a right slope thinly wooded with small oaks. This is also an old shore line, and has an approximate elevation of 875 feet above the sea, being probably the same as the 60-foot beach around Lake Winnipegosis.

Ochre and Vermilion rivers rise on the summit of Riding Mountain and flow down its eastern face in deep valleys that will be more fully described in the strictly geological part of the report. The first named Ochre and Vermilion rivers.

stream flows through woods to within a short distance of its mouth, while the Vermilion winds across the partly-wooded plains in a channel overhung by a belt of elm and maple.

Wilson River. Wilson River was not followed to its source, but it appears to rise on the north-eastern face of the mountain, where the escarpment is a longer and more gentle slope than usual, and thence it flows eastward across the level of Lake Dauphin plain to empty into the west side of the lake two miles north of the mouth of Vermilion River.

Valley River. The last and largest of the five streams is Valley River, which is stated to rise in Singoosh Lake in the interior of Duck Mountain, and thence flows southward through Angling Lakes into the bell-shaped valley that separates the Riding from the Duck Mountain. Near where it enters the valley it is joined by Short Creek flowing from the west in a deep, narrow valley, which connects at its western

Indian village end with the valley of Shell River. Here there is a small Indian village, where a band of Ojibways spend the winter. East of this village the river flows for some distance through a rolling morainic country, some of the hills being rounded and scattered with boulders, and others elongated in the direction of the valley, and composed of stratified sand and gravel. Further east the surface is much more even, and is underlaid by a fine white silt, resting on the glacial till. The woods are chiefly poplar and willow scrub.

Sandy plain. The country maintains much the same character to about the middle of range 22, where a trail branches off to the south. Here a sandy plain commences and extends to the eastern side of the same range, a few oaks being scattered over it here and there. At the above-mentioned trail the river flows in a valley eighty feet deep and half a mile wide. Land slides characterize its northern slopes which are covered with vegetation, while the south side rises in open gravel

Gravel ridge. terraces fifteen and thirty feet above the river. Near the eastern side of the above range two low gravel ridges are crossed at elevations of 1,280 and 1,260 feet above the sea, respectively, and near the western side of range 21 a strongly-marked gravel ridge is crossed at an elevation of 1,220 feet. The river here flows in a beautiful valley sixty-five feet deep, and near the bottom of the north bank is a spring of clear, cold water, smelling and tasting strongly of sulphuretted hydrogen.

About the middle of the same range the river cuts through a heavy gravel ridge on which a cart trail starts northward to Pine Creek Indian reserve, and still further east in the same range are two other ridges, the lowest of which has an elevation of 1,075 feet above the sea. Near this latter ridge is an old ford, and here the river is seventy-five

feet wide, flowing in an irregular valley a quarter of a mile wide and from thirty-five to fifty feet deep, with wide gravel flats on each side of the stream. A mile below this the banks are low, and covered with grass or timber.

Near its mouth the river flows through an open grassy plain in a channel about forty yards wide and from three to six feet deep, and empties into the lake over a bar of sand at the end of a long alluvial point.

MOSSY RIVER.

Lake Dauphin is discharged northward into Lake Winnipegosis by Mossy River, a beautiful winding stream twenty-two miles and a half long, from 150 to 200 feet wide, with an average depth of from two to four feet, and an estimated fall in its whole length of thirty-two feet.

Point of discharge.

It empties into the latter lake through low meadow land, which, in June, 1889, was two feet above the water, but is evidently often flooded. This meadow is about a quarter of a mile wide, and behind it on either side is a forest of aspen. An old trading post of the Hudson's Bay Company is situated on the east bank of the stream, three-quarters of a mile above its mouth, on a narrow strip of grassy land between the forest and the river. A mile above its mouth, in a direct line, the old Government location of the Canadian Pacific Railway crosses the stream, and near it are three exposures of Devonian limestone, the upper one forming a low cliff on the west bank. Above this cliff no rock in place is seen on the river.

Crossing of old C. P. R.

Boulders.

Two miles and a half above the Canadian Pacific Railway location there are some small islands in the middle of the stream, and between them the channels are filled with boulders, causing rapids with a fall of two to three feet. Throughout the distance to here the river is from 100 to 150 feet wide, with an average depth of four feet and a current of a mile an hour. It has no valley, except the channel in which it flows, and which it fills from side to side. Few bars of sand or gravel obstruct its bed, but boulders of gneiss and irregular fragments of white limestone are scattered along its banks. In places the boulders stretch across the river and form ugly rapids. As the water is generally muddy, these pebbles and boulders are coated with mud.

The bank is from ten to eighteen feet in height, fringed with grass and sedge close to the edge of the water, above which is a row of small willows, and on the level land on either side is a forest of white poplar, in which there are a few trees of ash and oak. On the west side much of the forest has been burned, and there are a few open

or thinly wooded spots by the river, while on the east side the bush is mostly green, with trees from six to eight inches in diameter.

Banks of till.

For the next two miles in a direct line the river is crooked, and is obstructed in four places by accumulations of boulders of gneiss and limestone which have fallen from the banks of loose light gray till. The banks are from eight to ten feet in height, the eastern one wooded as before, while on the west the river cuts into a long strip of open prairie, along which is an old cart trail to the Lake Winnipegosis salt springs. This bank is cut by several runnels, in one of which water was standing distinctly impregnated with salt. This level plain is underlaid by stratified alluvial sand or silt.

For most of the rest of the way to Fork River the stream flows by the side of this alluvial plain in a moderately straight course almost unobstructed by boulders or sand bars. It has a very easy current of from half to three-quarters of a mile an hour, is 150 feet wide and from three to four feet deep. The banks are from twelve to eighteen feet high, and composed chiefly of a loose light gray unstratified clay, often holding bands of well striated pebbles.

Fork River.

Fork River empties into the west side of Mossy River at a total distance of fourteen miles and a half from Lake Winnipegosis following the windings of the stream. At its mouth it is thirteen yards wide, and flows with a depth of an inch or two over a shallow bar of gravel. The water is dark brown. For half a mile above this the brook is about two feet deep, without current, and is choked with Algæ, Charæ and water lilies. At this distance the channel is blocked by large boulders of gneiss, between which the water flows in tiny streams. This channel spreads from side to side of a well-defined valley twenty feet deep, with [illegible] wooded with poplar. North of this brook [illegible] grove of poplar, oak, ash and maple, near which is a favourite Indian camping ground. For about seventeen miles westward across the almost [illegible] country the stream was not followed, but it was again crossed, and traced for several miles, in the vicinity of the main gravel ridge on which the trail runs northward to Pine Creek.

[illegible] River.

From Fork River to Fishing River, a distance of five miles along the winding channel, Mossy River is often obstructed by boulders of gneiss, and the banks are almost everywhere clothed with vegetation, most of which is poplar from three to eight inches in diameter.

Fishing River is a small sluggish brook flowing into Mossy River from the west. At its mouth it is forty feet wide, and without perceptible current. Ascending it for three-quarters of a mile, its width diminishes to twenty feet, and its depth to fifteen inches. Its bed is sandy, and its banks are fifteen feet high, and are wooded with poplar and oak.

Three miles from Fishing River, Mossy River flows from the north-west end of Lake Dauphin opposite some small boulder islands. Throughout this distance its banks are from eight to twelve feet high, sloping and wooded, and in many places a swift current flows over a bed of sand, clay and boulders. Head of river.

SWAN LAKE AND SHOAL RIVER.

Swan Lake lies seven miles south of Dawson Bay, into which it discharges through Shoal River. It is situated in a somewhat more undulating district than Lake Dauphin, the surrounding country being, as a rule, generally immediately underlaid by glacial till. It has a greatest length of twenty miles, a greatest breadth of eight miles, a shore line of seventy miles, and an area of 121 square miles. It contains nine small wooded islands, with a total shore line of fourteen miles and an area of one and a half square miles. The mean depth of the water is only five feet, and the greatest depth found in 1887 six feet. The bottom is soft and muddy. Its altitude, estimated from the fall of Shoal River, is twenty-seven feet above Lake Winnipegosis, or 855 feet above the sea. The writer was informed by Antoine Chenaye, a native half-breed, that about twenty years previous to 1889 the lake was at its highest stage, about six feet above its present level and that Shoal River then overflowed its banks. Some years previous to that date the lake was at its lowest level, when during the prevalence of a north wind Shoal River was dry at its head, and some of the men living in the vicinity used to race horses on the dry bed of a small lake near the mouth of Swan River. Position and extent. Altitude.

The east shore is generally a gravel beach, fringed with rushes at the bottoms of the bays, while the numerous points are surrounded by a sloping wall of boulders four to six feet in height. The boulders are chiefly of dark gray or reddish gneiss, while some are of limestone. The land rises very gently from the lake, and is wooded with poplar, with a forest of spruce in the distance.

At its south end the lake is very shallow, with a bottom of soft mud, so that it is difficult to get a canoe to the dry land. Beyond the muddy beach is a ridge of rounded gravel six feet in height, wooded with elm, behind which the country descends slightly and is wooded with birch, poplar, spruce and balsam fir. A spring of brackish water bubbling up at one place on the low beach, in which the writer gave a reading of 16 on the percentage salinometer. Close to this spring a bridle road to Pine Creek crosses the woods, and runs for a mile and a quarter across low land much obstructed by wire-tails, and then ascends a hill with a

total height, as determined by the aneroid, of 274 feet above the lake. On its face are six distinct terraces, the brows of which are 75, 113, 151, 170, 198 and 236 feet above the lake, the highest one rising in a long slope to the summit. The highest slope up to 236 feet is very steep, and appears to consist of sand and pebbles, while a great number of boulders of gneiss and limestone are scattered on the brow of this terrace.

Sand.

The summit is composed almost entirely of reddish sand, underlaid by rounded pebbles, with boulders of gneiss, limestone and white Dakota sandstone scattered here and there. The surface, which is slightly irregular, is thinly wooded with small Banksian pines and a few oaks. Towards the north-east the terraces are wider and more distinct than on the line of the trail. They are generally sandy and sparsely wooded, and on one of the higher terraces, at an elevation of about 200 feet above the lake, are many bare, rounded or hemispherical masses of white Dakota sandstone, from eight to twelve feet in height, with their planes of stratification horizontal, and apparently lying where they were eroded out of the soft sandstone of the base of the Cretaceous. They show no signs of glacial action, and have clearly been formed in post-glacial times, when the waves of Lake Agassiz cut this terrace in the face of the pre-existing slope.

Dakota sandstone.

The west shore is broken by long alluvial points, at the end of the most prominent of which Swan River empties into the lake. The islands off this point, near the centre of the lake, are ridges of boulders lying approximately in the direction of the glacial striation, wooded with groves of elm and maple, while the islands in the north end of the lake are composed of cream-coloured Devonian limestone polished and grooved by glacial action. These glacial grooves have a very persistent bearing S. 30° W., and the direction of the motion of the glacier is clearly shown by the fact that the summits are evenly rounded towards the north east, and ragged and broken towards the south west.

Drumlins.

Glacial grooves.

Shoal River House.

Near the south-east angle of the lake is Shoal River House, a trading post of the Hudson's Bay Company, beautifully situated on a small open plain close to the shore, with a gently sloping beach of gravel, extending to the edge of the water. In the open clearing the land rises gently to a total height of twenty feet above the lake, beyond which is a forest of spruce and poplar. The trail from the post to the mouth of the river is cut through this forest, and at a distance of a mile and a half ascends to a height of sixty feet above the lake on a ridge of sand and gravel wooded with Banksian pine.

Shoal River.

Shoal River flows out of the north-east angle of the lake over a low ridge of till, is nearly ten miles long, and has an average width of from

D. B. Dowling, Photo., Sept. 3, 1889.

ROUNDED BOSSES OF DAKOTA SANDSTONE.

ON A TERRACE 1053 FT. A.T. ON THE NORTH SIDE OF KETTLE HILL, MANITOBA. LAT. N. 52° 21' 30". LONG. W. 100° 37'

150 to 200 feet. The channel is generally not more than from six to ten feet in depth; the banks are sloping, and wooded with poplar and spruce, except on some open saline tracts, while the bed is often strewn with boulders, which are collected in places and form disagreeable rapids.

RED DEER LAKE AND RIVER.

Position and extent.

Red Deer Lake is a more or less rectangular sheet of water lying in the midst of a level alluvial plain north of Porcupine Mountain and west of Dawson Bay. It is thirteen miles long and nine miles and a half wide, has a shore line of fifty-one miles, and an area of one hundred square miles. It has a mean depth of five feet with a bottom of soft mud. Its altitude, estimated from the fall of the river, is forty-seven feet above Lake Winnipegosis, or 875 feet above the sea.

Shores.

The south shore was examined by the writer in 1889, while the others were surveyed by Mr. Dowling in the previous year. All are low, and except at one point on the south side no rock is to be seen. This latter side is fairly straight, and the beach in the bays is composed of sand and pebbles, while on the points it consists entirely of rounded boulders of gneiss and limestone, closely laid in an even slope, which rises at an angle of 10° to 12° from the water to edge of the spruce and poplar forest.

Red Deer River.

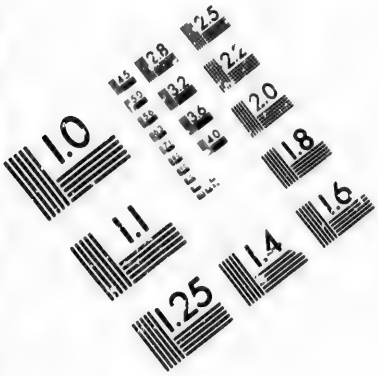
The Red Deer River empties into the west side of the lake at the end of a long alluvial point, and again flows from its south-east corner eastward towards Lake Winnipegosis. From its head, where the water is very shallow, to the mouth of Rice Creek, the river is wide, with a swift current, and boulders of gneiss form bars out into the stream.

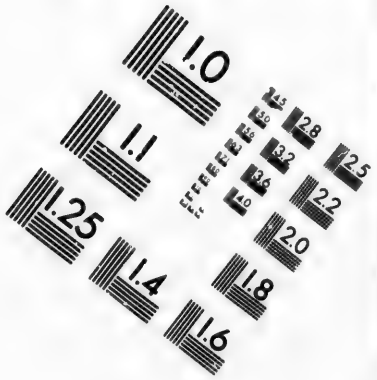
Rice Creek.

Rice Creek, called by the Indians Manomina Sipi, was ascended in a canoe for a mile and a half to a light rapid where the water flows over loose slabs of white limestone. It is a small creek from twenty to twenty-five feet wide, generally with a soft bottom, and occasionally almost blocked with grass. The country on both sides is low, level, and often saline, and the banks are overhung with willows. From the little rapid an open wet meadow extends southward for a couple of miles to a forest of spruce. The creek appears to flow down the face of the mountain in a narrow gorge, on the sides of which are some bare white cliffs, which appear very conspicuous from the islands and shores of Dawson Bay.

Long Rapid.

From the mouth of Rice Creek to the head of the Long Rapid, where a band of limestone crosses the stream, the river fills the channel from bank to bank, and with the exception of one slight rapid, flows





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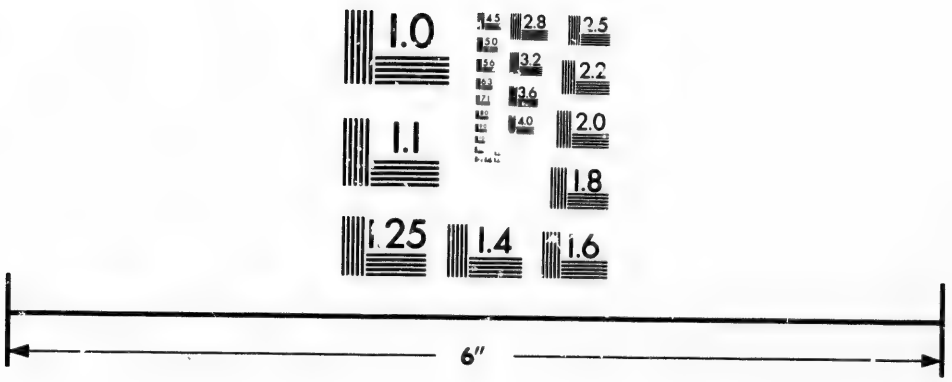

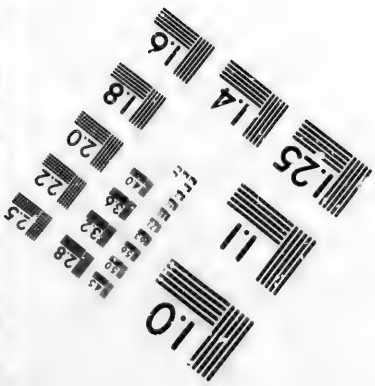

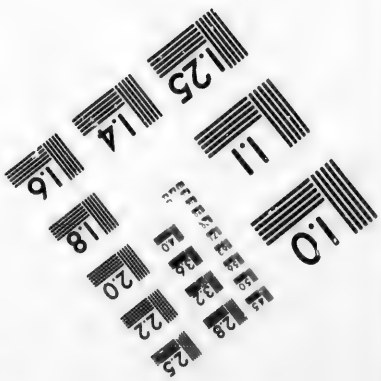

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with an even current and is moderately deep. The banks are low, and wooded with poplar and a few spruce. The limestone shows strong glacial grooves striking S. 75° W., or directly across the river. In the rapid, which is about a mile in length, the river is shallow, and filled with large granite boulders, while several wooded islands break up the channel. On the south bank, opposite these islands, is a watercourse coming from a wide saline area scattered with pebbles and boulders, and dotted with groves of poplar. Several springs of brine are rising in this flat, but all were so shallow and muddy that it was impracticable to test them with the salometer. A small stream of brine was flowing about five gallons a minute in the bottom of the watercourse.

Upper Salt Spring.

At the bottom of the rapid the river bends sharply towards the north-east, and is moderately deep for a mile and a half to a hill which rises on the north bank to a height of twenty feet, on the south side of which are some brine springs at which the Indians occasionally boil down the water to obtain a small quantity of salt. The hill is composed of limestone, and its north-east side, which is bare in places, shows indistinct glacial striæ trending S. 65° W., and on the south-east side is a little patch about three feet square of a light, reddish till holding rounded pebbles and cobbles of gneiss and limestone. The face of the hill, down which the brine is trickling, is covered with fragments of limestone, among which were many beautifully preserved fossils. A mile below this hill, which has been called the "Upper Salt Spring," a small salty creek, carrying about four gallons of water a minute, flows in from an open area towards the south.

Glacial striæ.

From this creek downwards to the lowest Salt Spring the river is one continuous rapid, flowing in a winding course through boulders, having a bare gravel beach on each side.

A short distance below the briny creek, and still on the south side, is a slightly elevated mound, from the centre of which is issuing a spring of brine flowing about ten gallons a minute. It has a temperature of 42° F., and gave a reading of 22 on the salometer.

At the bend below is a cliff of limestone, the summit of which is polished and scored with grooves running S. 80° W. Above the limestone is a hard, light gray clay, containing striated pebbles and boulders. Just below this cliff is a small salty brook flowing five gallons a minute, and in which the salometer gave a reading of 22°.

Higher banks.

From this point the banks ascend to a height of twenty feet, and consist in many places of cliffs of limestone overlaid by till filled with pebbles and boulders, most of which are granite or local rock, while some are Niagara limestone, containing *Pentamerus decussatus*. The lowest cliff of limestone on the river is also overlaid by till, and the

surface of the rock below the till is beautifully polished and striated in a direction S. 80° W.

The Lower Salt Springs occupy an open area of about 100 yards square on the north side of the river and twelve feet above it. The area is strewn with eroded boulders of gneiss and limestone, and small springs of brine bubble up every here and there, in one of which the brine seemed to be very concentrated, giving a reading on the salometer of 75 per cent. Lower Salt Springs.

Below these springs the banks are low and alluvial, and there is but little current in the river.

CEDAR LAKE AND SASKATCHEWAN RIVER.

Cedar Lake is an irregular body of water lying in the extreme northern part of the area included in the map, and is separated from Lake Winnipegosis by a narrow belt of high land from four to five miles in width, which cuts across what would otherwise appear to be a single natural basin. Its greatest length is thirty miles, its greatest width is fourteen miles, it has a shore line, within the map, of 108 miles, and an area of 330 square miles. Its depth is from thirty to forty feet, and its elevation above the sea 828 feet, both these measurements being the same as those for Lake Winnipegosis. Position. Extent.

At its western end the lake receives the waters of the Saskatchewan River in the middle of a little archipelago of small rocky islands. On the outermost and largest of these islands the early French traders are stated to have had a fort. This fort or trading post, which was called Fort Bourbon, was founded by one of the sons of Sieur de la Verendrye in 1741. He reached the site by travelling northward from Fort la Reine (Portage la Prairie) across lakes Manitoba and Winnipegosis. The island is thickly wooded with spruce. At its north end is a low cliff of limestone with a gravel spit projecting beyond it, behind which is a pleasant harbour for small boats. At its south end is a rounded hook of gravel inclosing a shallow bay. Old Fort Bourbon.

From the mouth of the Saskatchewan southward the shore of the lake is low, with a more or less sandy beach, behind which is a level spruce and tamarack swamp. With the sand and debris on the beach are scattered many particles of fossil resin that have been washed down by the Saskatchewan River from the Cretaceous shales and sandstones higher up the stream. The south shore is without prominent cliffs, and consists of stretches of even sandy beach between salient points piled high with large boulders of gneiss. Fossil resin.

Rabbit Point.

Rabbit Point is a low, sandy promontory on the north shore, invested with a mournful interest, as here lie the remains of Benjamin Frobisher, one of the early partners of the North-west Company. In the troublous times just before the union of the North-west and Hudson's Bay Companies he was taken prisoner by the latter and carried to York Factory, from which place he escaped in the autumn of 1820. He ascended the Nelson and Saskatchewan rivers on his way to a trading post on Moose Lake, but at Rabbit Point, worn out by hunger and fatigue, and while his Indians were absent at Moose Lake in search of relief, he expired beside his lonely bivouac fire.

Rocky Islands

North-east of Rabbit Point an arm of the lake extends for twelve miles past low wooded shores and small rocky islands, where gray cliffs of limestone peep out here and there from under the covering of dark green spruce. At the end of this arm of the lake a deep, narrow channel, known as "The Narrows," runs between a small island and the south shore. Here the Saskatchewan River may be said to commence again, but its characters are entirely different from those of the sluggish stream which flows into the west side of the lake. Instead of filling, it is rapidly deepening its channel, tumbling and sliding down rocky limestone ledges in wild rapids, between which are quiet stretches. One of these expands in Cross Lake into a comparatively large body of water.

Grand Rapid

The Grand Rapid (the last of these rapids and the most interesting feature on the Saskatchewan River) has a total fall in five miles of seventy-one feet, the most of which is concentrated into two miles in the middle of the distance. In these two miles the river has cut a deep, narrow gorge in the horizontal limestone, part of which gorge is post-glacial and part pre-glacial in age.

Tramway.

To overcome the difficulty of transporting goods and boats past this rapid by hand, the Hudson's Bay Company engaged Walter Moberly to build a tramway three miles and a half in length past the rapids. This was done in 1877, and on the eleventh of September of that year Lady Dufferin, who, with Lord Dufferin, the Governor-General of Canada at that time, was travelling in the west, drove the last spike in this remote railway.

Descent of the rapid by John Fleming.

The following excellent description of the descent of the Grand Rapids below the east end of the old portage is given by Mr. John Fleming :—

"In running the rapid we followed as closely as possible the instructions given to us by our old guide on the plains (John Spence) who had often piloted the old N. W. Co.'s *north* canoes down its entire length. In attempting, according to his directions, to cross

from the north to the south side of the rapid in order to get into what was reported to be the best channel for a small canoe, such was the fierceness of the current and the turbulence of the great surges and breakers in the middle that we were nearly engulfed; and although every nerve was strained, we were swept down with impetuous velocity, and did not get near the other side till we were about three-quarters of a mile below our starting point. We were then impelled with astonishing swiftness along the south side of the torrent, often in dangerous proximity to the rugged wall of rocks bounding the channel, and now and then whizzing past—almost grazing—sharp rocky points jutting out into the river, against which the thundering waters seethed and foamed in their fury. During the descent the voyageurs exerted themselves to the utmost of their strength, and evinced an admirable degree of coolness and dexterity.

"The Grand Rapid is acknowledged by those who have witnessed it, and who have had opportunities of traversing the great river systems of the continent, to be unsurpassed in magnificence and extent, as well as in volume of water."*

PHYSICAL GEOGRAPHY AND GEOLOGY

COUNTRY WEST OF THE LAKES.

General character.

This region is entirely underlaid by the soft and easily-eroded Cretaceous shales and sandstones, which are lying in an undisturbed and almost horizontal attitude. The streams are small, and in many cases are not now actively eroding their channels, and old escarpments soon crumble down to easy slopes and become overgrown with vegetation, so that good natural exposures are infrequent. Very often the lines bounding the different formations have therefore necessarily been drawn on hypsometrical evidence. It has consequently been found inadvisable at present to separate the description of the geography from that of the older geology of this district.

For the sake of greater accuracy, the river valleys and trails followed will be described in succession, beginning with those in the south-eastern portion of the district.

Ochre River.

The Ochre River rises on the summit of the Riding Mountain and flows in a general direction N. 25° E. for twenty-five miles to its mouth at the southern extremity of Dauphin Lake. In the upper part of its course it flows in a wide and gradually deepening depression, in the

*Report of the Assin. and Sask. Expl. Expedition by H. Y. Hind, Toronto, 1859, p. 78.

bottom of which it has cut its own distinctive valley. Where it crosses the line between ranges seventeen and eighteen, the valley is seventy feet deep, the banks are composed of light gray unstratified boulder-clay, and the bed of the stream consists of rounded pebbles of limestone, &c., with a few rounded fragments of rather hard light gray clay shale. Beyond, the hills rise both to the east and to the west to a height of about 700 feet. In most cases these hills are thickly wooded with spruce and poplar, but there are a few steep, naked banks, apparently of the light gray clay shale, that everywhere constitutes the topmost Cretaceous beds on this mountain. It was to the top of the hill west of this valley that Prof. H. Y. Hind climbed in his trip from Dauphin Lake to Riding Mountains in October, 1858.

High hills.

Following the river downwards from the crossing of the above line, which is at an elevation of 1,250 feet above the sea, the bed of the stream soon becomes very much obstructed by large boulders of gneiss and limestone, many of the latter of which are striated. In the bank, croppings of dark gray soft clay shale begin to make their appearance from under the overlying till, and soon become conspicuous in all the scarped banks at the convex bends of the stream. A mile south of the Correction Line a bore-hole was sunk to a depth of 150 feet. The rock is a soft, unctuous dark clay shale, showing in many places an efflorescence of sulphate of iron, and often containing between its layers thin sheets of small crystal aggregates of selenite. A hard band of limestone runs along close to the edge of the water. Mr. A. McDonald, who sank the above mentioned bore-hole, informed me that with the exception of a 2-inch seam of coal, which was passed through at a depth of forty-four feet, the whole 150 feet was sunk in dark gray clay shale similar to that seen at the surface.

Pierre shales.

Bore hole.

For two miles and a half below this point, or for one mile and a half below the seventh Correction Line, similar shale is seen in the banks of the river. Close to the crossing of the Correction Line a ridge crosses the river, which in ascending section shows twenty-five feet of dark gray clay shale overlaid by fifteen feet of rounded pebbles and boulders bedded in a sandy matrix. The ridge is 450 feet wide, slightly rounded on top, and rises sharply for forty feet from low land of about the same height on both sides. The course of the ridge is N. 88° E. It is thickly overgrown with poplar mixed with some oak, maple (*A. spicatum*) and elm, while birch, ash-leaved maple and spruce are growing on the adjoining low lands. Beneath this heavier timber there is a thick growth of Amelanchier and Pembina bushes. There are other ridges both above and below this one, on one of the former of which is an Indian trail leading to the south, but this one is the most clearly defined of any that cross this river.

High gravel ridge.

Just above this ridge a number of fossils were collected from the dark shale and an included band of limestone, consisting of *foraminifera*, oysters, Inocerami and fragments of plates of fishes. Fossils.

For a mile and a half below this ridge similar soft dark clay shale crops out at intervals, including in one place a bed of hard sandstone holding numerous remains of small oysters.

The whole of the Cretaceous beds seen on this river appear to be lying almost or quite horizontal, the total thickness seen from the first outcrop below the line between ranges 17 and 18 down to the last outcrop seen on the river being about 175 feet. Cretaceous beds.

Before reaching the above-mentioned lowest outcrop of dark shales, the hills on either side have fallen away, and the river has left the Riding Mountain and now flows across the lacustrine plain at its foot towards Dauphin Lake. Its channel becomes ten to forty feet deep, forty feet wide and very crooked, the wide gravel flats and bars seen higher up the stream having here almost entirely disappeared. The banks show neither the underlying shale, nor till, but are composed entirely of stratified clay often mixed with a considerable quantity of sand. Winding channel

The channel is usually skirted with a dense belt of trees, such as cottonwood, balsam-poplar, elm, &c., behind which are many beautiful meadows sprinkled over and separated by groves of aspen and willow.

Edwards's Creek rises in the Riding Mountain a short distance south of the 7th Correction Line, and flowing parallel with the last-named stream, joins the Vermilion River a few miles above its mouth. Edwards's Creek.

At the crossing of the Correction Line the valley is only forty feet deep, and the bed is at an elevation of 1,820 feet above tide. The valley, however, rapidly deepens, soon becoming a narrow gorge 160 feet deep with very precipitous scarped banks of horizontal light gray shale, often appearing red from iron stains. Deep gorge.

Three-quarters of a mile below the Correction Line and just below the entrance of a small stream of slightly greater size from the east, there is a steep bank on the east side showing an exposure 160 feet in height. The upper thirty feet consists of sandy boulder clay or till containing small pebbles, most of which are of limestone, but some are of granite. Below this is 130 feet of slaty light gray clay shale, much jointed and generally showing iron stains on the jointage faces. A quarter of a mile down the stream, but at thirty-five feet lower level, and at an elevation of 1,720 feet, this light lead-grey slaty shale is seen to be underlaid perfectly evenly and conformably by fifteen feet of dark grey Millwood shale. The difference between the two shales is quite clearly marked, especially as the lower shale weathers out into irregular High cliff of Odanah shale.

rhombic particles, while the upper weathers into thin flakes. For a mile and a half below this the banks of the valley consist largely of irregular slides of the overlying slaty shale, but in several places near the river a soft dark gray clay shale was seen, crumbling into clay, precisely like the Pierre shales of the Bow River and Upper Saskatchewan. Near the lower end of the above distance this shale includes a band of lenticular nodules of clay ironstone. This is at an elevation of 1,500 feet above the sea.

Boulders. For the next three miles down the river, or to the mouth of a small spring brook coming from the east, no exposures of the Cretaceous rocks were seen. The channel is at first very much blocked by Archæan boulders, and fragments of ironstone as large as cobble-stones are quite numerous, but soon the boulders disappear and the bed of the stream Odanah shale. is composed of pebbles of Odanah shale, with some of quartzite and gneiss and a few of ironstone. The banks, too, are at first composed largely of pebbles of light gray slaty shale, but this soon changes to stratified sand overlying unstratified till, and the stratified sand again to stratified clay.

Gravel ridge. Half a mile above the mouth of the spring brook a gravel ridge twenty-five feet high crosses the course of the stream, composed, to the bottom, of stratified sand and gravel. The gravel consists almost entirely of smooth lenticular pebbles of lead-grey clay shale, mixed with a few small pieces of ironstone, and pebbles of quartz and gneiss as large as marbles.

Niobrara shale. At the mouth of the spring brook, at an elevation of 1,271 feet above tide, a dark gray clay shale, mottled with small particles of calcareous material, makes its appearance, and the valley becomes rapidly deeper and the bed of the stream is filled with large gneissoid boulders.

Three-quarters of a mile below the mouth of the creek a bed of rather hard, gray, argillaceous limestone, containing Inoceram[illegible], crops out four feet above the bed of the creek, overlaid by fifteen feet of dark gray mottled clay shale, and this is again overlaid by a bed of unstratified till holding large gneissoid boulders. Three-quarters of a mile further down, where the river crosses the southern line of township 24, the valley is fifty feet deep, the lower thirty-five feet of the bank consisting of dark gray mottled clay shale, the top of which consists of a bed one to two feet in thickness of white or light yellow chalky limestone, containing numerous fragments of Inocerami and scales of fishes similar to those Foraminifera. found on Ochre River, as well as numbers of foraminifera belonging to the genera *Textularia*, *Rotalia*, &c. This is the same band as the one mentioned in the last exposure, but it has become less argillaceous and much softer and more chalky. When struck, it emits a slight odour of petroleum.

It is directly overlaid by eight feet of rounded gravel, mostly of limestone and shale, but mixed with pebbles of quartzite and gneiss. This gravel is moderately fine throughout, but much the finest near the surface. Ascending the bank, this escarpment is seen to be the section of a gravel ridge extending across the country parallel to the face of the mountain and rising in easily rounded slopes ten feet above the country on either side. On going a little further north a steep slope is encountered, descending abruptly for fifty feet, and the above ridge runs parallel with this slope and about 300 yards back from its brow.

From the foot of this slope the country descends gently to Lake Dauphin, being either open meadow land, scattered poplar coppice, or swamp.

Vermilion River.

Vermilion River rises near the summit of Riding Mountain in several small streams which flow together either in, or near, the foot of the mountain. The branch followed rises a short distance north of Lake Audet and flows northward for ten miles till it is joined by a similar stream from the west, and throughout this distance the waggon trail to the Lake Dauphin settlement follows its eastern side, at first through groves of poplar separated by prairie openings, and then through thick though not very heavy timber, consisting of aspen and balsam poplar, with some spruce, tamarack and small birch. Five miles south of the fifth Correction Line a small stream joins the Vermilion River from the east, flowing in a narrow gorge-like valley. At the point where the trail crosses this valley it is ninety feet deep, and the elevation of the bed of the stream is 1,750 feet above tide. Just above the crossing there are several small crumbling exposures of light lead-gray fissile Odanah shale, similar to the upper beds on Edwards's Creek ; and two miles farther down the main stream, similar shale again crops out. At the trail crossing, a short distance above the forks, the stream is twelve feet wide, and when crossed in July, 1887, was six inches deep, with banks consisting of pebbles of gneiss and limestone.

Odanah shale.

High cut banks.

Two miles and a half below the forks, on the south side of the river, there is a cut bank ninety feet high, consisting at the top of twenty feet of dark gray friable clay shale holding bands of nodules of white or light gray limestone very much veined with calcite, and weathering down into a white powder, while below it, is seventy feet of dark slate-gray clay shale, emitting, when struck, a strongly bituminous odour. At the bottom, these beds contain numerous acicular crystals of selenite. A mile below this point the trail crosses the river at an altitude of 1,310 feet ; 300 yards above the crossing is a high cut bank of horizontal slate-gray clay shale, mostly very friable and holding many small crystals of selenite. In the bank were some thin bands of ironstone and large

Trail crossing.

Fossils.

nodules coated with a layer of calcite, which has the appearance of being the partly decomposed shell of Inoceramus. A fragment of a Baculite was also found. About a mile south of the crossing, a high hill rises 325 feet above the level of the river at this point, or to a height of 1,635 feet above the sea. On the top of it may be seen small irregular outcrops of soft crumbling light gray shale, with bands of nodular clay ironstone a short distance below the summit. Fifty feet below the summit a considerable thickness of this shale is exposed lying quite horizontally.

At the crossing several low outcrops of shale are exposed close above the edge of the water. It is here very tenacious, has a greasy feel, cuts like cheese, and emits a strong bituminous odour.

Boring on Vermilion River.

A well was bored near this point by the Manitoba Oil Company to a depth of 743 feet, in the hope of obtaining petroleum. The following is the report of this well as published by the writer in the Trans. Roy. Soc. Can., Vol. ix., Sec. iv., pp. 102–104.

"*Boring on Vermilion River.*

Position.

This boring was sunk by the Manitoba Oil Company on the west bank of the Vermilion River, a short distance below the crossing of the Strathclair and Lake Dauphin trail, in Township 23, Range 20, west of the Principal Meridian.

Date.

In the spring of 1887 a percussion drill was hauled north from Strathclair station, on the Manitoba and North-western Railway, and the well was drilled to a depth of 292 feet, when an accident happened to the machinery which delayed the work for a time.

In the following year the drill was moved a short distance down the valley, work was resumed, and a final depth of 743 feet was reached.

From a comparison of the sections, the second well is found to have been begun nine feet lower, geologically, than the first, and therefore the levels of all the specimens obtained from it have been corrected by the uniform subtraction of nine feet, in order to give them their proper position in the total section.

For the log of this well, with illustrative specimens, I am indebted to the kindness of W. R. Baker, Esq., Superintendent of the Manitoba and North-western Railway, who was one of those most deeply interested in the success of the well.

The record as given below is compiled from the log kept by the driller and the results of my examination of the specimens.

HEIGHT OF SURFACE AT BORING ABOVE SEA, 1,300 FEET.

Synopsis of record.

Number.	Description of Material passed through.	Thickness of layer in feet.	Depth of bottom of layer from surface.	Height above sea.	Remarks.
1	Soft, dark gray clay shale	95	95	1,205	Pierre (Millwood series).
2	Fragmental limestone	4	99	1,201	Niobrara.
3	Gray calcareous shale	124	223	1,077	Niobrara.
4	Dark gray fissile shale	178	401	899	Benton.
5	Coarse sandstone, with pyrites	19	420	880	Dakota.
6	Compact white limestone	120	540	760	Devonian.
7	Blue-gray clay shale	10	550	750	Devonian.
8	White gypsum	15	565	735	Devonian.
9	Red shale	110	675	625	Devonian.
10	Shale and limestone	68	743	557	Devonian.
11	Red shale	At bottom.			Devonian.

Pierre shales.

No. 1.—Specimens from 30, 48 and 91 feet show this to be a soft, dark gray, non-calcareous clay shale belonging to the Millwood series of the Pierre shales, similar to that seen in the naked and almost vertical cliffs washed by the river a few hundred yards above the trail crossing.

Niobrara shales and limestones.

No. 2. This is a hard band that was spoken of as "sandstone" by the driller. It consists almost entirely of fragments of the prisms of the shells of a large *Inoceramus*, mixed with fragments of *Ostrea congesta?* This evidently represents the band of sandstone-like limestone that outcrops on the Assiniboine River below the mouth of Cypress Creek, and is also seen at several places along the eastern face of the Riding Mountain. It lies at the top of the Niobrara formation.

No. 3.—Specimens collected from 146 and 164 feet show this to be a mottled, blue-grey, calcareous clay shale or marl. Under the microscope it is found to be mixed with prisms of the shells of *Inoceramus*, fragments of the shells of *Ostrea congesta?*, minute portions of fish skeletons and quite a large number of foraminifera. These comprise such forms as *Globigerina cretacea* and several species of *Textularia*, and with them are associated many *Coccoliths* and *Rhabdoliths*. These evidently represent the characteristic shales and marls of the Niobrara formation.

Benton shales.

No. 4.—Specimens obtained from 213–247 feet consist of a dark blue-gray, fine-grained, unctuous, non-calcareous clay shale, breaking down into thin flakes. These represent the typical Benton shales.

Dakota sandstone.

No. 5.—A specimen from 411 feet consists of grains, varying greatly in size, of clear, white quartz. Some of these grains are quite angular

in shape, and many are stained on the outside with iron. With the sand grains are mixed small cubical crystals of pyrite. In a paper published in "The American Journal of Science" for September, 1890, the writer gave the Dakota formation in this well a thickness of 55 feet, but he has since found reason to believe that a specimen of sandstone labelled 369 feet is not to be depended on, and the record has therefore been altered as above to agree with the log kept by the driller, thus reducing the thickness of the Dakota to 19 feet.

Devonian limestone.

No. 6.—A specimen from 509 feet is a moderately hard, fine and evenly-grained, light gray limestone, through which are scattered small subangular grains of colourless quartz and grains of pyrite. A specimen marked 510–540 feet consists of similar limestone, with fragments of light and dark gray clay shale.

Shale.

No. 7.—A specimen from the lower part of the band consists of a mixture of light blue-gray clay shale, particles of limestone, some few crystals of colourless quartz, and particles of opaque white gypsum from the top of the band below.

Gypsum.

No. 8.—A specimen marked 550–565 feet is made up largely of fragments of opaque white gypsum, mixed with a few fragments of colourless quartz, and small nodular masses of pyrite.

Shale.

No. 9.—A specimen marked 565–645 feet consists of a soft, light brownish-red, fine-grained shale, mixed with fragments of light gray shale and particles of limestone. In the clayey mass are also many minute and very perfect crystals, as well as irregular particles of clear transparent quartz.

Shale and limestone.

No. 10.—A specimen from 718 feet consists of a light pink, hard, compact, fine-grained limestone that effervesces strongly in HCl., leaving a similarly coloured fine clayey precipitate. With the limestone are many fragments of a fine-grained, white sandstone, and a very few white, opaque particles of gypsum. A specimen from 740 feet is a mixture of fragments of cream-coloured limestone and reddish shale. It effervesces strongly in HCl., leaving a residue of dark gray and buff-coloured shale, fine grains of quartz and small particles of pyrite.

Absence of fossils.

No fossils have been obtained from the Palæozoic rocks drilled through in this well, and in the absence of direct stratigraphical correlation their exact age cannot at present be determined. However, their geographical position clearly shows that they are of post-Silurian age, and the absence of dolomites excludes them from the middle or Winnipegosan formation of the Devonian. It is also altogether unlikely that fossils would have been so uniformly absent from the drillings if some of the lower highly fossiliferous beds of the Manitoban, or Upper Devonian formation had been passed through. Many of the

limestone fragments from near the bottom of the bore correspond closely with the limestone outcropping near the mouth of Mossy River, at Point Wilkins, etc., belonging to the higher portions of the Manitoban formation exposed in natural sections, and the known south westerly dip of a few feet to the mile would account for the difference in elevation of the beds.

It is therefore probable that the Palæozoic beds passed through in the Vermilion River boring represent an upward continuation of the Point Wilkins limestones, and therefore in the main, overlie the highest Devonian beds seen on the shores of Swan Lake or Lake Winnipegosis." Upper Devonian.

Following the valley of the river for three miles below the trail crossing, the banks are high, and generally consist of soft dark gray Cretaceous shale, though in places unstratified till composes the greater part, or even the whole, of the cliff. At one of the latter places the scarped bank consisted of forty feet of light yellowish-gray till, in the top of which was imbedded a layer of large transported boulders, overlaid by twelve feet of yellowish-gray stratified sandy clay without boulders. At the end of the three miles, and at an elevation eighty feet lower than the river at the crossing, the bank is composed of similar dark gray soft shale, while at the edge of the water a bed four feet in thickness of hard sandy limestone crops out, holding remains of oysters and Inocerami. As the river is followed down still further this limestone band gradually ascends in the banks, till at the end of a mile it is seventy-five feet up the bank, and is underlaid by mottled gray shale through which are scattered fragments of Inocerami and remains of fishes. In Four Mile Creek, which is a small stream flowing in from the east half a mile below the last mentioned exposure, this hard band is seen ninety feet above the level of the river at its mouth. Fifty feet below this band of hard limestone there is a band of rather hard light grey shale, and as the river is descended this band becomes better defined, till at the outer, steep slope of the mountain it is a band of rather hard white limestone crossing the face of the escarpment at a height of ninety feet above the river. This band of white limestone contains many Foraminifera of the genus *Textularia* with great numbers of *Coccoliths*. For one-third of a mile below the edge of the escarpment similar mottled shale crops out, but the banks have now become low and often swampy. At this point Mr. Arch. McDonald sank a bore-hole 120 feet, and found similar shale to the bottom, and the same man informed me that similar shale crops out in low exposures for a mile further down the creek, beyond which nothing is seen but drift and alluvium. Three miles further down, where the river was again seen, the banks consist for several miles entirely of bedded clay. The

Vermilion River below the trail.

Limestone.

Bore hole.

river flows in a narrow winding channel, has a muddy bed, often scattered with pebbles, and belts of timber skirt its sides, beyond which the country is generally open, grassy meadow land.

Wilson River. Wilson River rises on the north-east side of the Riding Mountains and flowing eastward, falls into Dauphin Lake a short distance north of the mouth of Vermilion River. Where first seen in township 25, range 22, the banks are twenty feet high, with steep grassy slopes to the edge of the water. The elevation at this point is 1,300 feet above the sea. Following the stream eastward the valley gradually deepens till the banks are about 100 feet high, and then it again becomes shallow and like the other rivers in the district flows in a winding channel through almost level partly wooded country to its mouth.

Banks of till. At the point where the river was first seen and for three miles and a half below it, the banks consist of light gray sandy unstratified clay containing numbers of irregular pebbles and boulders, but about the centre of the distance a low ridge of rounded gravel, with an elevation of 1,288 feet above the sea, crosses the valley, running in a N. N. W. and S. S. E. direction. This ridge was the highest ancient lake beach observed on this river, and west of it the country gradually rises in the low gently rounded swells and undulations typical of the western plains.

Niobrara shale. At the lower end of the portion of the valley above mentioned, and at an approximate elevation of 1,190 feet above the sea, a light gray mottled calcareous shale of Niobrara age outcrops on the side of the bank ten feet above the river and ten feet above it is a band of cream-coloured marl containing fragments of such fossils as *Ostrea*, sp., *Inoceramus problematicus*, an obscure fragment of an Ammonite, and great numbers of foraminifera belonging to the genera *Globigerina* and *Textularia*. The beds have a light dip S. 60° W.

Descending the river for the next three miles the banks vary considerably in character, but everywhere the bottom is found to be composed of clay shale, sometimes very much darker than that first seen, and often containing interstratified beds of soft white unctuous clay. The beds are throughout horizontal and often contain fragments of oysters, Inocerami and scales of fishes. The exposures of shale are in some places fifty feet high and are generally overlaid by a light yellowish-gray compact till, often, especially towards the bottom, containing a great number of large boulders of gneiss and limestone

Gravel ridge. At the point which has now been reached, a strongly marked ridge of rounded gravel having an elevation of 1,150 feet, crosses the country in a general direction parallel to the one already passed higher up the river. This ridge is devoid of timber and thinly grassed on top

and on it the Indians have one of their main trails into the country to the north. After cutting through it the river takes a course a little south of east and flows in a thickly wooded valley, with high banks that often show good exposures of horizontal mottled gray calcareous clay shale. Two miles east of this ridge is a cut-bank showing a very good section of fifty feet of this shale, in which, fifteen feet from the bottom, is a bed of what appears on first sight to be a light brown lamellar sandstone, but which, on closer examination, is found to be composed of minute dark brown fragments of teeth and bones of fishes, cemented together by a calcareous cement. This shale is highly phosphatic. A specimen of it was analysed by Mr. Hoffmann of this Department, and he reports that it contains 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. The extent of this phosphate bed could not be determined at the time, but if it should prove to be large, it will furnish a very valuable source of supply of phosphate of lime to renovate the wheat lands of Manitoba and the adjoining Territories. In many of its characters it approaches closely to the coprolite beds which are so extensively worked for phosphate of lime both in France and England. Phosphatic shale.

For a mile below this outcrop of phosphatic shale, small naked scarps of dark gray shale occasionally overlook the river, and then the valley becomes more diffuse, and appears to assume the characters of the Vermilion and Ochre river valleys in the lower parts of their courses, with banks composed entirely of stratified alluvial sand and clay.

Valley River is stated to rise in Singoosh or Weasel Lake in the north-eastern portion of the Duck Mountains. It flows first south-westward and then southward over a drift covered region, till it emerges in the wide valley north of the Riding Mountain. It is here a beautiful clear stream thirty feet wide and two feet deep, flowing over a bed of rounded limestone pebbles. The valley which it has entered is more or less open and grassy throughout, though, of course, dotted with groves of poplar and willow, and there is here a pleasant looking little Indian village, consisting of several well-built log houses, with good, though diminutive, stables, around which a small amount of land has been tilled, and a considerable quantity of hay is annually cut. The large number of new graves on the tops of the surrounding knolls testified to the fearfully high mortality rate prevailing among these people, who are gradually diminishing in numbers, not because a sufficient number are not born into the world, but because all the ordinary laws of hygiene are so entirely neglected that only a few of the very hardiest ever reach maturity. Valley River. Indian village.

From the Indian village the river flows eastward for ten miles. For the first mile the valley is generally open, with a gently rolling surface.

Morainic ridge.

For the next two miles the cart trail on the north side of the river winds over and among morainic hills, which appear to extend across the valley and along the face of the escarpment on either side. The hills are in the shape of rounded knolls, which may be joined together in irregular ridges, often one hundred feet high, among which are numerous little rounded freshwater ponds, without apparent outlet. The sides of these hills are covered with large gneissoid boulders and small pebbles of quartz, gneiss and limestone of very irregular shapes. Some of the latter are striated, though all are very much covered with calcareous tufa. But one geological section was seen in these hills, and it consisted of twenty feet of light brown slightly sandy calcareous clay, containing a few pebbles and small boulders. One of the latter was a lenticular nodule of ironstone, evidently derived from the Cretaceous rocks. The clay was quite unstratified and a large number of the pebbles were of limestone, almost all of which showed glacial striæ.

Near the eastern side of this hummocky ridge, a small stream flows from the north, and its bed is covered with large irregular boulders of gneiss. The altitude of the mouth of this stream, where it flows into Valley River, is about 1,362 feet.

For a mile and three-quarters below the mouth of this creek the bottom and sides of the valley are much more even, but a great many large gneissoid boulders are scattered over the flats on each side of the stream.

Kames.

Below this boulder-strewn portion of the valley, the banks diverge to a certain extent and a kame-like ridge, or series of ridges, begins and continues eastward for four miles down the middle of the valley. These ridges have a generally oval contour, with sides rising in rather steep slopes from the bottom of the valley. Their tops vary from slightly undulating, to quite rough and hummocky, and are generally more or less thickly strewn with gneissoid erratics. The most westerly of these kames is three-quarters of a mile in length and 250 paces wide on top. On its south side, where the river impinges against it, there is a naked bank showing an exposure forty feet in height, though on account of slides it was impossible to measure the different beds of which it was composed. At the top the exposure consists of rounded and water-worn pebbles and boulders of limestone, gneiss, &c. The pebbles are separated out and arranged in horizontal layers. The lower part of the bank consists of sand without pebbles.

Below these kames the river turns and flows for ten miles in a general north-easterly direction. The valley which had become very much

diffused, again becomes well defined and rather narrow. The banks are sloping and either grassy or covered with small aspens, and the soil of the valley and the surrounding country is occasionally sandy, but is usually a fine clay formed from the weathering of a fine light gray or white silt that overlies the boulder clay. Sloping banks.

Very few exposures of the underlying beds were seen, and these consist almost entirely of light gray unstratified till, containing numerous striated pebbles and boulders of limestone, &c. In some places the irregular surface of the till is overlaid by from two to three feet of fine grained yellow or gray silt with a well defined stratification, which follows closely the surface irregularities of the till.

At the end of this stretch the banks of the valley are thirty feet high, and the river is flowing over a bed of pebbles many of which are distinctly striated. Here the river takes a great sweep to the south, while the trail turns to the east and, after crossing a level plain for five miles, comes to its north bank again where another trail crosses it and running south-eastward to the Riding Mountain joins the Vermilion River trail near the forks of the latter stream. The valley of Valley River is here half a mile wide, eighty feet deep, and the stream flows over a bed of rounded water-worn pebbles and boulders. The north side is very uneven and probably much slidden, but on the south side there is a bottom land consisting of stratified sand and gravel fifteen feet above the water, fifteen feet above which is a well-defined terrace of similar deposits, beyond which the bank rises to the general level, at an elevation of 1,270 feet above the sea. Vermilion River trail. Valley terraces.

From this point the river flows in a general north-easterly direction for ten miles. For the first four miles the valley is very rough and uneven and the trail keeps some distance back from it on a slightly undulating, gravelly or sandy plain, thinly covered with a sparse growth of short grass, on which are standing here and there a few stunted oaks, while to the north are seen numerous groves of small aspen. This sandy plain is an ancient delta deposit formed by the stream that here flowed into the western side of Lake Agassiz, when this large post-glacial lake stood at one of its highest stages. A quarter of a mile before the trail again touches the bank of the river a low ridge of rounded gravel is crossed, the most westerly ridge seen on this river, having an elevation above the sea of 1,290 feet. The trail reaches the bank of the river on another of these ridges of rounded gravel, its even grassy surface having been a favourite camping ground for the Indians hunting through the district. The top of this ridge, which is seventy feet above the river, is seen to be composed of stratified sand and gravel, but most of the lower portion of the face of the bank Ancient delta. Gravel ridge.

is covered with slides, so that very little of the underlying rock is seen. What is exposed, however, is a mottled gray Niobrara shale with bands of almost white chalk marl, holding fragments of *Inoceramus problematicus* and many foraminifera of the genera *Globigerina*, *Textularia*, &c. Near the foot of the bank is a spring of clear cold water tasting and smelling very strongly of sulphuretted hydrogen.

A mile and a quarter below this ridge, a small stream joins Valley River from the north, and at its mouth is an excellent exposure of six feet of horizontal, gray, mottled clay shale holding a broad form of *Inoceramus problematicus*. Below the mouth of this creek the banks again become largely composed of boulder-clay, and the underlying shale was not seen for a distance of three miles and a half, when a dark gray clay shale was seen in an exposure extending sixteen feet above the river. The boulder-clay or till which overlies this shale and forms the banks for most of the remaining distance, is, as usual, a light gray unstratified sandy clay containing numerous pebbles and boulders, most of the limestone ones of which show distinct glacial striæ. Two very distinct gravel ridges cross the river in this distance. One of them, two miles and a quarter below the mouth of the small creek, was very carefully examined. It is the same ridge that was noted as being the largest ridge on the Wilson River, and on it the Indians have their main pitching track towards the north along the eastern face of the Duck Mountains. The ridge is here being rapidly cut away by the stream, and the following descending section is distinctly shown:

Section of post-tertiary deposits.

	ft.	in.
Sandy and pebbly loam	2	3
Well stratified gravel in a matrix of light yellow quartz sand. The pebbles are mostly limestone, though some are of granite, and are rounded or slightly lenticular in shape. The gravel is beautifully interstratified with beds of sand, and is arranged in finer and coarser layers, the pebbles increasing in size, from above, downwards	8	0
Gravel, similar in character, but not so well rounded, a few of the limestone pebbles showing glacial striæ	1	6
Fine yellowish quartz sand very irregularly interstratified with coarse sand, gravel and plastic clay	1	9
Very coarse sand or fine gravel		7
Plastic yellow clay	1	6
Unstratified light gray sandy clay or till holding polished and striated pebbles and boulders of gneiss, limestone, &c	35	0

The line between the last two is very indistinct. In this section just at the top of the bed of fine rounded gravel a number of sharp-angled and apparently chipped fragments of quartzite were found. Two of them were roughly in the shape of arrow heads, and one was a very thin flake. The others were very irregular. Associated with them was a broken fragment of one of the toe bones of a moose or elk. These irregular fragments were all lying with their longer axes horizontal, and were overlaid by a sandy loam, which had apparently been deposited as a coarse sand, and which has since been affected by weathering and by the growth of vegetation over it to about the depth at which these "chipped flint" are lying. This slightly loamy sand is plainly though not very clearly stratified and includes towards the bottom, and above the "chipped flints" many thin water-worn lenticular pebbles of shaly or thin bedded limestone. Chipped pieces of quartzite.

A mile north-east of this ridge, another ridge runs away to the north-west, and for a mile below it the banks of the river show dark gray unctuous clay shale to a height of from fifteen to twenty-five feet. At the end of this mile the banks become low and sloping for a mile at least, and a man who was with me stated that he had been down the river for four miles further and the banks continued of the same character throughout. Wherever seen the unctuous Cretaceous shale contained some fragments of the shells of Inocerami.

Where the banks fall away another gravel ridge crosses the country, and is said to continue towards the north-west, though it was impossible to follow it rapidly through the thick woods. Low country.

The ridge west of it, with an elevation of 1,084 feet, was, however, followed for a long distance. Its surface is underlaid by fine gravel, and is generally even and lightly covered with short grass, forming a grassy plain from 100 to 200 paces wide. Pitching ridge.

On either side is a fringe of stunted oaks beyond which the ground is very swampy and is thickly wooded with poplar and spruce. The ridge is quite level, resembling a beautiful gravel road running between long rows of trees. For five miles it runs N. 20° W., maintaining the same open, avenue-like character. At the end of this distance it is cut across by Drifting River, a small stream flowing south-eastward to join the Valley River. Its valley is here forty feet deep and a quarter of a mile wide, and is very thickly wooded with maple and willow. Beyond this break of a quarter of a mile the ridge is again encountered, but for a mile and a half it is very irregular, being in some places almost cut away by Drifting River, which here flows southward along its western side. Beyond the point where the creek first strikes the ridge it is again beautifully rounded with a width of 150 feet and rises about ten feet Drifting River.

above the level of the surrounding country. Three-quarters of a mile from the creek the cart trail to Pine Creek joins this ridge, coming from the one to the west of it, and the ridge then continues for thirteen miles almost due north to Fork River, being in this distance broken through by two small streams flowing eastward, the beds of which are covered with pebbles and gneissoid boulders, but neither of them show any indications of shale or rocks of local origin. Throughout the southern part of the distance the ridge was lightly wooded with poplar, after which it is thickly wooded with heavy poplar, and long marshes or shallow lakes extend along its western side. Around these there is some good white spruce, most of which have lately been burnt. At the end of this distance, Fork River, a small stream ten feet wide and two feet deep, cuts across the ridge from the west. On the west side of the ridge and south of the river a beautiful wide grassy meadow stretches for several miles to the south, on the north end of which, close to the stream, is an old Indian shanty.

Pine Creek trail.

Fork River.

For the next eight miles the summit of the ridge was not followed, but for the most part, if not for the whole distance, it could be clearly seen from the cart trail to the west. In north latitude 51° 38′ 15″ the cart trail comes again to the ridge and after following it northward enters a grove of large spruce, in which it crosses South Pine Creek, here twenty-five feet wide. Beyond this stream the ridge is found to present a beautiful open, though narrow stretch, a mile in length with the river flowing southward along its western side and a spruce forest to the east, until a small Indian village is reached. Here a band of Indians from Pine Creek Reserve pass the winter in small but substantial log houses. They obtain an abundant livelihood by hunting and trapping in the immediate vicinity. Moose, bear, otter beaver, marten, fisher, fox and skunk are the principal game.

Indian village

From this village a cart trail thirty miles in length strikes off to the Hudson's Bay Company's post and Indian Reserve, near the mouth of Pine Creek. This trail is described on a succeeding page.

From the Indian village on South Pine Creek the ridge continues in a direction N. 25° W., being generally low but moderately well defined. It is wooded with small aspen, among which are scattered a few stunted oaks. To the west, a meadow, a quarter of a mile wide, follows the ridge for several miles, while to the east is a thick growth of small spruce. Five miles north of the village the ridge is cut across by Little Pine Creek (*Minégo Sipi Wanichan-sin*, The Child of Pine Creek), a small stream twelve feet wide flowing over a bed of pebbles and boulders. It is said to flow into North Pine River. Two miles and a quarter further north another small tributary of North Pine Creek,

Ridge becomes wooded

about six feet wide, crosses the ridge. Between these two creeks the ridge is twice broken through, first by a narrow gully that possibly at one time was the channel of Little Pine Creek, and secondly by a wide shallow depression.

North of this small tributary the low gravel or sand ridge was followed for three miles and then for one mile was lost in a heavy spruce and poplar forest south of North Pine Creek. North of North Pine Creek it was further followed as a low but still distinct ridge for three miles, until an accumulation of heavy timber and windfall made it necessary to leave it, and to strike westward across a tamarack swamp to an almost vertical escarpment sixty feet in height, along the foot of which is a line of rounded cobbles, apparently on the level of the next higher Lake Agassiz beach. The total distance through which this gravel ridge has been practically continuously traced northward from Wilson River is fifty miles. Time would not permit of levelling it instrumentally, but a careful series of barometric readings seem to show that it is about a hundred feet higher at the northern than it is at the southern end, having a rise northward of about two feet to the mile. This agrees closely with the observations already made on these beaches in Southern Manitoba and the adjoining States.

Ridge obscured.

A typical example of the country west of Lake Winnipegosis may be seen along the cart trail from the ridge just north of South Duck River to the Hudson's Bay Company's trading post, near the mouth of Pine Creek. East of the Indian village the trail runs eastward for four miles and a half, through country wooded with small spruce and poplar, across tamarack swamps, and little sandy plains sparsely wooded with Banksian pine, to a rounded ridge of sand, twelve feet in height, through which South Pine Creek flows in a comparatively shallow channel. This sand ridge has an elevation, as determined by the barometer, of 1,047 feet. The trail follows it in a N.N.W. direction for a mile, and then leaves it and turns north-eastward for two miles across a willowy or grassy plain, often underlaid by sand, to another ridge about thirty feet below the last, composed of sand and small gravel. It also has an elevation of about twelve feet above the surrounding country, an average width of 150 feet, and is lightly wooded with small poplar and large Banksian pine.

Pine Creek trail.

South Pine Creek.

The trail continues northward on this ridge for a mile, and then turns north-eastward, and, after crossing a level tract of country, ascends the point of a sandy ridge with about the same elevation as the one just left. This ridge is also followed by the trail for a couple of miles, in which distance it is interrupted in places, and generally has an extensive sandy plain stretching away to the north-west of it. In

places it is lightly wooded with Banksian pine, poplar, and a few small oaks.

Ford. Two miles and a half from the north-eastern end of the ridge the trail crosses Pine Creek at a good ford, over rounded boulders and cobbles of gneiss and dolomite. From the crossing, north-eastward to the trading post, the trail is never at any great distance to the south-east of the river. For the first three miles it crosses an almost level plain, generally overgrown with willows, with here and there burnt stumps of spruce and poplar, and on which are tracts more or less thickly scattered with boulders. On this plain the old location of the Canadian Old location C.P.R. Pacific Railway is crossed, and near it a well rounded gravel ridge, 200 feet wide and six feet above the surrounding country. The elevation of this ridge, as given by the Canadian Pacific Railway survey, is 960 feet above the sea. Thence the road passes over grassy plains and through poplar woods, in which a few boulders may occasionally be seen. A few low and intermittent sandy ridges, the heights of which were not determined, mark old shore lines of Lake Agassiz.

Upper pitching ridge. Returning to Valley River a high, well-defined gravel ridge has already been recorded a mile to the west of the one followed, and about fifty feet above it. On this ridge the cart trail to Pine Creek, and the ancient hunting trail of the Indians to the eastern face of Duck Mountain, starts northward from Valley River. The ridge is also well defined southward to Wilson River, and is probably continuous with those most strongly marked near the face of the escarpment on Vermilion and Ochre rivers.

For four miles northward from Valley River it is gently and evenly rounded, rises twelve feet above the level of the surrounding country, and finally spreads into a gravel plain a quarter of a mile wide. South-
Small lake. west of this plain is a small lake of beautifully clear water, to the east of which, extending across the gravel ridge, is a fine grove of oak. Very few boulders were seen on the ridge, but some were found near the border of the lake, chiefly of grey and reddish gneiss, but one was of dark green trap, and a few were of Palæozoic limestone.

After passing through the grove of oak the ridge is again seen stretching towards the north as a long line of grassy prairie through the centre of a forest of spruce and poplar. A mile and a half north of the lake Drifting Creek strikes the western side of the ridge and from there follows it for two miles, till at length it cuts through it in a valley twenty feet deep, but quite narrow. This stream is flowing over a bed of boulders and pebbles derived from the superficial deposits, and shows no signs of the underlying Cretaceous rocks.

Drifting Creek. On the north side of Drifting Creek the ridge becomes wooded with poplar and the cart trail leaves it, and strikes eastward over a flat

marshy tract covered with dead poplar and willow until the ridge already described is reached, up which it turns as far as Fork Creek, when it again turns westward and after crossing Fork Creek reaches a ridge which is at the same elevation above the one we have last followed as the main ridge at Valley River, of which it is doubtless a continuation.

Fork Creek. Fork Creek is a small stream ten feet wide and two feet deep at this point. It rises on the eastern face of the Duck Mountain, and flows eastward to join the Mossy River in the north-east corner of township 29, range 20 W. For much of its course it flows through a more or less low swampy country, and its water is consequently of a decidedly brownish colour. At the trail crossing, just below the upper of these two ridges, its bed is composed largely of limestone pebbles as well as boulders and pebbles of gneiss, but there are also many fragments of a rather hard grey clay shale. The upper course of the stream is entirely through drift deposits, but close to the last-mentioned gravel ridge horizontal dark grey clay shale, representing the summit of the Benton or the base of the Niobrara shales, is seen in several small exposures close to the edge of the water.

Cretaceous shale.

From the camping place on the Pitching Ridge, just north of this creek, and at an elevation of 1,180 feet above the sea, a pack trail turns off to the west. Where this trail crosses the creek a low sandy ridge, ten feet higher than the last, runs N.N.W., and a mile further along the trail, or two miles from the Pitching Ridge, a well-defined ridge of rounded water-worn gravel, with an elevation of 1,235 feet above the sea, rises six to eight feet above the level of the surrounding country. Its general bearing is N. 25° W. Two miles further along the trail, another ridge from 300 to 400 feet wide, ten feet high, and 1,287 feet above sea level runs off parallel to the last, and consists, like the others, of rounded gravel. Half a mile beyond this is another low ridge of rounded gravel, and three-quarters of a mile beyond it again is yet another similar ridge, with an elevation of 1,365 feet above the sea, well defined where there is low land behind it, but in other places it is less distinct where it is backed by low cliffs, that have formed the shore when the waters of Lake Agassiz stood at the height of this ridge. This is the highest level that the water appears to have reached.

Higher ridge.

West of this highest ridge the country becomes more undulating, and the soil is a dark, sandy clay, covered with numerous pebbles and boulders, which are all more or less distinctly angular, and show no sign of having been rounded by water action. They are simply weathered out of the underlying boulder-clay which everywhere forms the surface.

Undulating country.

Upper pitching ridge.

North of Fork Creek the Pitching Ridge is evenly rounded, and about twelve feet above the level of the surrounding country, consisting, on the top at least, of fine, rounded, water-worn gravel, with pebbles chiefly of limestone. A prairie area here has evidently been a favourite camping ground for the Indians. From here the ridge follows a general direction of N. 20° W. For three miles and a half it is open or lightly wooded with poplar, and carts were taken along it without much difficulty, but at the end of this distance it is cut across by a small tributary of Fork River, twelve feet wide and a foot deep, flowing in a rather shallow valley 700 feet wide, and thickly wooded with large spruce.

After crossing this creek the cart trail again turns to the north and leaving the ridge continues through a forest of large poplar and spruce to a long open meadow lying west of the lower ridge already described. This meadow in 1889 was moderately dry and covered with long grass, while a lake a mile and a quarter long extended through it, but in years of high water it is doubtless an impassable marsh. The trail follows the meadow in a N.N.W. direction for three miles, with a forest of small spruce and tamarack to the west, and then rises a few feet to the top of the lower ridge.

Travelling northward in 1887 the carts were left on the higher ridge south of the tributary of Fork River, and the course of the ridge was followed on horseback and with packhorses.

Ridge more sandy.

North of the creek the ridge becomes thickly wooded with heavy poplar and spruce, but still it is well defined though now often more sandy than was usual further south. To the west it is bordered by a grassy marsh, while towards the east lies an extensive spruce-covered swamp. The ridge here, and as far north as we followed it, maintains the direction N. 20° W.

South Pine River.

For five miles it continues to maintain much the character of that just described, when it is cut across by South Pine River, a stream of clear brownish-coloured water thirty feet wide and two feet deep with sandy banks covered with a deep coating of moss or sedge. Its bed is a coarse rounded limestone gravel, and there is no sign on it of any of the underlying Cretaceous shales or sandstones.

North of South Pine River the ridge for a mile is an open grassy prairie, beyond which it begins to be more and more thickly wooded, till six miles north of the above river the pack trail leaves it and turns on to the lower ridge. For the next three miles it was not followed, though it was often seen to the west of the trail, but it was again reached on the banks of North Pine River. It was followed north-north-westward for a mile and a half, when it became so covered

with a heavy windfall of burnt spruce and poplar that further travel along it was impossible. Its summit here has an approximate altitude of 1,250 feet above the sea.

When the trail leaves the lower ridge a short distance further north, it ascends the face of a steep escarpment sixty feet in height, which would appear to have been cut by the waves of Lake Agassiz when its waters formed the beach that we have last been following. The top of the hill is pretty thickly scattered with boulders, and the hill itself is probably a glacial accumulation of the character of a moraine or drumlin. Steep escarpment.

Throughout all the distance that this ridge was followed north of Fork Creek, it maintained much the same character, being from 150 to 250 feet wide, and six to eight feet above the level of the surrounding country, rising on both sides with an easily rounded slope, and almost level on the top. The top generally consists of sand or fine gravel, which becomes coarser at a depth of a few feet, as can be seen in places where trees have been blown down, and their out-torn roots have left deep holes in the otherwise level surface.

All these ridges are doubtless connected with some of those to be described further north, but the country is so densely wooded that it was impossible to follow them continuously.

From the trail on the Pitching Ridge another trail branches to the west up North Pine River, on which several high gravel ridges are crossed, and from which many good exposures of the underlying Cretaceous shales may be seen. As far as the writer's observation went, the lowest exposure of these shales on the river is on its north bank where it cuts through the Pitching Ridge last described. The following descending section is here shown: — North Pine River.

Benton shale.

	ft.	in.
Horizontally stratified gravel, with pebbles of gneiss and limestone up to three inches in diameter	6	0
Light gray unstratified till, with irregular pebbles and a few boulders. The lower portion almost entirely local	10	0
Dark gray thin-bedded clay shale	4	0
Soft white clay, with sweetish taste	0	6
Dark gray thin-bedded clay shale, with many small crystals of selenite, to water	6	0

The clay and shale appear to represent beds about the summit of the Benton formation.

The trail runs along the top of the south bank of the valley, on gradually rising ground, through poplar woods. The valley gradually becomes deeper, and a quarter of a mile or more in width.

Niobrara shale.

About a mile up the valley from the Pitching Ridge the bank shows the following section :—

	ft.	in.
Light brown sand	5	0
Soft light gray mottled shale in thin beds, weathering into small flakes, and forming a steeply sloping cliff	15	0
Hard white clay	0	1
Light gray mottled chalk marl	5	0
Hard white clay	0	2
Soft light gray mottled chalk marl or marlite in beds ranging in thickness from three inches down to a thin shale, and weathering into a vertical cliff. It contains many shells of a large *Inoceramus*, *Ostrea congesta ?*, fragments of fish bones, and many foraminifera, among which *Globigerina Cretacea* is particularly abundant	5	0

These shales and chalk marls are typical of the Niobrara formation.

Half a mile further up the river, and just east of the trail crossing, a similar excellent exposure of foraminiferous Niobrara shale may also be seen.

Trail crossing

At the crossing the valley is seventy feet deep, with wide stretches of level bottom land, through which the river winds in a channel filled with boulders. West of it the trail continues along the north side of the valley for nearly five miles. For the first mile and a half it passes over a sandy tract, generally wooded with Banksian pine, on which three gravel ridges are crossed at respective elevations, as determined by aneroids, of 1,383, 1,402, and 1,439 feet above the sea. Opposite these the valley is 100 feet deep, and the banks are composed of till from which a large number of boulders are falling, while the bed of the river is filled with large boulders.

Delta plain

West of the highest of the three ridges just mentioned, the trail passes for a mile and a quarter across a wide plain, thickly wooded with small Banksian pine, and chiefly underlaid with brown sand and water-worn pebbles, some of which are as much as eight inches in diameter, though for the last quarter of a mile the soil is finer and more silty, and over the silt a few boulders are scattered. This sandy plain would appear to have been an old delta deposit formed by the prototype of North Pine Creek, when Lake Agassiz was at one of its highest stages. There is a rise of forty or fifty feet from its eastern to its western side. The river, opposite this latter point, flows in a valley fifty feet deep, ten feet of this being its immediate channel. Twenty feet above the river is a terrace stretching from bank to bank of the valley, underlaid by alluvial gravel consisting of pebbles and boulders up to a foot in diameter, of gneiss and Devonian limestone.

For the next two miles and a quarter the country is rolling or hilly, many of the hills being literally covered and probably largely composed of boulders, chiefly of gneiss. The whole tract is clearly morainic. Here the trail reaches the river which is twenty-five feet wide, and approximately 1,627 feet above the sea. Just above this point, and on the north side of the river is a bank, fourteen feet high, showing from top to bottom light slate-gray horizontally stratified clay shale, breaking down readily into small angular fragments. The beds clearly belong to the Pierre formation, and doubtless to its lower portion. Though no large and typical fossils were observed, the shale, under the microscope, was found to contain many radiolaria apparently similar to those found on Bell River, but generally so corroded that Dr. Rüst, who described those from the latter place, was unable to identify the species. Moraine. Pierre shales.

This exposure of Pierre shale is close to the foot of the main escarpment of Duck Mountain, where North Pine Creek emerges from it in the bottom of a wide sloping valley from 300 to 400 feet deep. Wherever any other scarped banks were seen on its sides, they appeared to consist of light gray till.

On the south side of the valley a long esker rises to a height of 150 feet above the bottom land, and a scarped bank on its southern side shows the following section :— Esker.

	ft.	in.
Light yellowish gray unstratified clayey till, containing many irregular striated pebbles of limestone and gneiss	6	0
Cut off obliquely by, and lying unconformably under the above is a light yellowish-gray, horizontally stratified, fine sand or silt, free from pebbles	3	6
Coarse red sand and small pebbles	0	4
Fine sand, slightly coarse at bottom	1	9
Stratified gravel, with pebbles up to four inches in diameter imbedded in a matrix of coarse sand. A number of the pebbles are of a light gray till, different, however, from that above	5	0
Horizontally stratified fine light brown sand	3	6
Very light gray slightly coarse sand	1	0
[C]overed	50	0
[D]ark gray, horizontally stratified, tenacious clay or clay shale	1	0

The summit of the mountain to the south, as well as its face, is strewn with boulders of Archæan gneiss, &c., and Devonian limestone.

Following the Indian hunting trail northward from North Pine River, a branch of South Duck River is crossed in north latitude 51° 52′. It is twenty feet wide and flows over a bed of gravel in a narrow South Duck River.

South Duck River.

valley through the ridge. The banks are composed at the bottom of twelve feet of light gray mottled Niobrara shale holding *Ostrea congesta*, above which are thirty-four feet of badly exposed interbedded layers of till and stratified sand and gravel.

A short distance north of this stream the trail reaches a well rounded gravel ridge, with an elevation of about 1,360 feet above the sea; and five miles north of the last mentioned stream it crosses the main branch of South Duck River which here flows in a valley seventy feet deep, with a channel thirty-five feet wide. From the top of the ridge a beautiful view can be had of the wooded face of the Duck Mountain, where a dark line of heavy spruce forms a rich background to the lighter green of the intermediate poplar forest, while the distant sky line rises and falls in easy undulations.

The almost vertical bank of the valley beneath shows the following section of Lake Agassiz deposits and Niobrara shales:—

	ft.	in.
Stratified light brown sand underlaid by gravel.....	22	0
Dark gray horizontal fissile mottled clay shale holding fragments of *Ostrea congesta?*, *Inoceramus* sp.; and a few small species of foraminifera.....	14	0
Light gray mottled clay shale, the beds becoming thicker below.....	31	0

A mile further north, in a low exposure of similar shale on the banks of the same river, *Belemnitella Manitobensis* and *Loricula Canadensis* were also found.

Trail to Duck Mountain.

Between these two streams, at a small grove of oaks, a bridle trail turns off the ridge towards the west. For a mile and a quarter it runs through poplar forest, passing a beautiful grove of large elms, and then for three-quarters of a mile follows a gravel ridge with an elevation of about 1,400 feet above the sea. From this ridge it makes straight up the easy slope of the side of the mountain, through woods of poplar and spruce, and over hills often thickly strewn with boulders, to some small brooks flowing into North Pine River. Here the country becomes thickly wooded with small pine and tamarack, and the trail strikes across stony morainic hills to the head of Favell River.

Returning to the east side of the mountain, the main trail follows the ridge for two miles and a half north of the crossing of South Duck River, and then turns north-eastward and runs through a tamarack swamp, intersected by drier belts covered with poplar, and over land composed largely of sand and boulders, to the north point of an old sand spit or beach fifty feet in height. This beach stretches away to the south, and is generally composed of rounded gravel, though its surface

Sand spit.

is also thickly strewn with boulders. Its summit has an approximate elevation of 1,290 feet above the sea.

Along its eastern side, and fifty feet below it, runs another well defined ridge of rounded gravel, which continues northward to North Duck River, just north of which it is crossed by the old location of the Canadian Pacific Railway, at an elevation of 371 feet above Lake Winnipegosis, or 1,199 feet above the sea. Another similar ridge is also crossed by the old location survey, a short distance further east, at an elevation of 1,149 feet above the sea. North Duck River.

The North Duck River where crossed, close to the foot of the ridge, is thirty-six feet wide, and on the 10th of October, 1887, was six inches deep, with a bed of sand and pebbles. The banks were all of stratified gravel, and nothing was seen of the underlying Cretaceous beds.

Beyond North Duck River the ridge continues northward for about three miles, in which distance it is often scattered with many boulders of gneiss. At the end of this distance it turns to the west around the north-eastern angle of Duck Mountain, and runs up the valley of Swan River, but it was not definitely followed further.

SWAN RIVER AND TRIBUTARIES.

Swan River rises on the western side of the Porcupine Mountain and flows in a general south-easterly direction to the crossing of the Second Initial Meridian. A brief account of this portion of the stream is given by Prof. Macoun in the Rep. of Dept. of Interior, 1881, pt. I., pp. 81–85.

A short distance below the crossing of the Second Initial Meridian Snake Creek flows into Swan River from the south, in a deep wide glacial valley, which is a continuation northward of that followed by the Assiniboine below Fort Pelly. Snake Creek rises in a marsh north-west of Fort Pelly and close to the elbow of the Assiniboine River, and I am informed that in high water, when this river overflows its banks its waters run into Snake Creek and Swan River. Snake Creek.

On the east side of Snake Creek valley, just above its mouth, is an extensive triangle-shaped prairie, sloping from the higher land to the south-east to within about ninety feet of the level of Swan River. This prairie is irregularly undulating, in some places being almost level, in other places low rounded hummocks alternate with shallow depressions, but everywhere it is thickly covered with boulders of reddish and greenish gneiss from two to three feet in diameter. The valley of Prairie.

Snake Creek to the west of this prairie is about 1,500 feet wide and seventy-five feet deep, while towards the west its banks rise into a prominent spruce-covered ridge. Close to its mouth the valley is blocked by high rounded boulder-strewn morainic hills, through which the creek has again cut a narrow channel.

Police barracks.

On the northern side of the above prairie the Mounted Police had a large barrack which was burnt by a prairie fire in 1884. The place where the fort stood is now strewn over with charred wood, pieces of rusty iron, &c.

Half a mile south of the old fort, the telegraph line on the old location of the Canadian Pacific Railway crossed this prairie from east to west, and here the town of Livingstone was intended to have been laid out. The level of the bottom of Snake Creek valley, as laid down on the profile of the old location of the Canadian Pacific Railway, is 567 feet above Lake Winnipegosis, or 1,397 feet above the sea.

Swan River bore.

On the alluvial flats close to the banks of Swan River and a few paces east of the mouth of Snake Creek, Dr. Selwyn in 1874 and 1875 had a bore-hole sunk to the depth of 501 feet to ascertain quickly and certainly whether coal was to be found in any considerable quantities within working distance of the surface. The height of the surface here as compared with the nearest points on the old location was found to be about 1,360 feet above the sea.

"The specimens of the strata taken out are nearly all of dark blue, gray or black shale, and hold *Inoceramus*. At 259 feet a calcareous band, about nine feet thick, was passed through. This and the lowest twenty feet of shale, rather slaty, show organic remains, small spines and fish scales."*

The shale here passed through is probably the same as that seen lower down on Swan River, and belongs to the Niobrara formation of the Cretaceous.

Swan River.

Following the river downwards from the mouth of Snake Creek, Mr. Dowling saw some small exposures of dark gray clay shale, mixed with some thin bands of white unctuous clay; and on the bars in the river, at the crossing of the trail from Fort Pelly to Swan Lake, a large number of fragments of dark gray clay shale, mixed with clay ironstone, near which were found pieces of sandstone, holding *Ostrea congesta ?*. A short distance below the crossing, dark gray friable rather soft clay shale is sliding out of the bottom of the bank, mixed with some dark brown clay ironstone.

*Alfred R. C. Selwyn. Rep. of Prog, Geol. Survey, 1875-76, p. 292.

An alluvial flat occupies the bottom of the valley, which is here half a mile wide and 150 feet deep. Through the alluvial deposit the river has cut a winding channel that but seldom impinges on the sides of the valley, which are doubtless chiefly composed of Cretaceous rocks. Valley.

The sides of the valley are everywhere sloping and covered with small aspen. In many places the bottom is open and grassy, but the river channel is always fringed with willow and ash-leaved maple.

For eight miles from a point two miles below the crossing place, the river was not examined, but, where seen, three miles above the mouth of Bear's Head River, the valley was but thirty-five feet deep, and the immediate banks were low and thickly wooded. The river was 150 feet wide, with a bed of large boulders, over and through which the water was flowing.

Half a mile below Bear's Head River, the banks of Swan River are sixty feet high, and show at the bottom fifteen feet of horizontally bedded dark gray clay shale of the Niobrara formation, including harder calcareous bands, holding Inocerami, oysters and bones and scales of fishes. Nodules of iron pyrites are also falling from the face of the bank. Niobrara shale.

This shale is overlaid by three feet of light gray unstratified till, holding many polished and striated pebbles, on which is resting eight feet of coarse red stratified sand and gravel. Copious springs of water, highly charged with calcareous material, flow from this bed, and form a heavy tufaceous deposit on the face of the cliff. The sand is overlaid by several feet of light gray laminated clay. Till and sand.

Half a mile further down the river, where the bed of the stream has an elevation of about 1,240 feet above the sea, the bank is thirty-five feet high and its bottom is composed of dark gray clay shale, holding bands of soft limestone, in which were found fragments of *Inocerami*, *Ostrea congesta*, *Serpula semicoalita* and *Belemnitella Manitobensis*. This is overlaid by a coarse reddish stratified sand, which, within a short distance, is either quite loose, loosely cemented together by calcareous material into a soft friable sandstone, or bound together by calcareous or ferruginous cement into a hard sandstone, or conglomerate. It is quite evident that this is the same deposit as the sand overlying the till at the last named exposure. This sand is overlaid to the surface by twelve feet of more or less distinctly laminated light gray clay. Niobrara limestone.

North-west of this part of the river, and at a distance of about four miles from it, Thunder Hill rises as a high isolated prominence from the middle of the plain. Its height, as given on the plans of the old Thunder Hill.

Thunder Hill. location of the C. P. R., is 1,167 feet above Lake Winnipegosis, or 1,997 feet above the sea. The height as determined by two aneroids during 1887, was 1,848 feet, and allowing that there was some point a little higher than that reached, the highest point would not exceed 1,900 feet, which may therefore be taken as the true height of the hill. The following section was measured by Mr. Dowling, who collected specimens of the different beds. The rock was usually seen in small isolated exposures.

At the summit, at an altitude of 1,848 feet, were twelve feet of drift deposits, holding numerous small irregular pebbles. This would appear to be till.

Immediately below it lies a soft dark gray unctuous Cretaceous clay shale, holding a thin band of soft white clay, to a thickness of eleven feet at least, often stained with a yellow incrustation. At a height of 1,770 feet is an exposure of about thirty feet of a rather hard soapy shale.

Niobrara shale. At a height of 1,750 feet is the top of an exposure showing ten feet of light yellow clay shale, below which is fifty-five feet of a light gray chalky shale, descending about the middle into a chalk marl at 1,715 feet, and at the bottom showing a band of a hard gray limestone holding several fossils, viz., *Ostrea congesta*, *Inoceramus* sp. with very thick shell, *Inoceramus*, possibly a large form of *problematicus*, and *Cladocyclus occidentalis*. The chalk marl also contains several genera of foraminifera, viz., *Textularia*, *Discorbina* and *Globigerina*, with Coccoliths and Rhaboliths. Below this the face of the hill is covered with slides and the country slopes away to the level of the plain.

Extension of the terrane. The band of limestone or chalk marl, which is here seen at an elevation of 1,700 feet, is very similar to the Niobrara limestone on the Valley, Wilson and Vermilion rivers, ninety miles S. 35° E. from this exposure, where it has an approximate elevation of 1,200 feet. 105 miles further in the same direction, in section 36, township 8, range 11, and at an elevation of about 900 feet above the sea, a band of hard gray limestone, ten feet thick, outcrops on the banks of the Assiniboine. It is very similar to the lowest calcareous band on Thunder Hill, and contains precisely similar fossils. In all three localities the marl is overlaid by a dark gray clay shale, which in both of the southern exposures, at least, would appear to belong to the Pierre formation.

Thickness of the terrane. The greater height at which the chalk marl and limestone occur in Thunder Hill may be due to the light south-westerly dip of the strata, or it would appear more probably to be due

to a thickening of the underlying Cretaceous sandstones and shales, as all the information at hand goes to show that the underlying Palæozoic limestones are practically horizontal on their extreme western outcrop, from Mossy River to the east end of Red Deer Lake. If these limestones extend horizontally under the shales of the Duck and Riding Mountains, the Cretaceous beds lying below the layer of chalk marl would show a thickening of 500 feet on going north-westward from Vermilion River to Thunder Hill. If an even dip towards the south-west is assumed from the line of outcrop of the limestones, the evidence of thickening would be still stronger in favour of a thickening of the Niobrara-Benton formation towards the north-west, for while the outcrop on the side of Thunder Hill is forty-two miles from the approximate line of outcrop of the underlying Palæozoic limestones, the outcrop on Vermilion River is only about twenty-eight miles from the same line, so that any dip of the surface of the limestone in this direction should show a still greater increase in the thickness of these beds towards the north-west. That the surface of the underlying limestone does not rise towards the south-west from its line of outcrop, is shown by the bore-hole that was sunk near the mouth of Snake Creek, the bottom of which is about the same level as the surface of Swan Lake.

River banks of stratified sand.

Returning now to Swan River the next point examined, below the exposures near the mouth of Bear's Head Creek, was about five miles east of Thunder Hill, where the river makes a sweeping bend towards the north. The banks are here about thirty feet high, and consist of fine, regularly stratified sand. Four miles further down the river, one of the gravel ridges, of which mention has already been made, crosses the valley, its surface being open and grassy. It is locally known as the "Square Plain," and consists, like the other similar ridges, of rounded water-worn limestone gravel. No complete section of it was seen, the upper twenty feet was covered with slides, but the lowest fifteen feet, down to the river, consists of unstratified glacial till, holding many finely striated pebbles. The underlying Cretaceous beds are entirely concealed.

For twelve miles north-east of the "Square Plain" the river was hastily examined, but its banks appeared to consist entirely of superficial deposits.

The underlying Cretaceous rocks now reappear, but their character is different from that of the shales near Bear's Head River. The dark gray unctuous clay is present on the top, below it the clay is lighter in colour and more compact, and is interbedded with layers of sandstone.

Near Tamarack Creek.

Two miles below Tamarack Creek the following section is exposed on the north bank of the stream :—

	ft.	in.
Light coloured stratified sand	4	0
Very irregularly stratified soft plastic clay	6	0
Bed of same containing numerous large pebbles	1	6
Light yellow horizontally stratified fine-grained slightly clayey sand, containing a few striated pebbles	15	0
Band of dark Cretaceous clay with small irregular concretions of pyrite	0	2
Horizontally stratified fine white very soft sandstone, streaked with bands of red and black	2	3
Similar sandstone containing large red lenticular nodules of hard sandstone	0	9
Soft white sandstone with dark bands	6	6
Covered	3	0

Stratified dark blue clay at the bottom of which is a band of hard sandstone containing a great number of well-preserved specimens of an *Ostrea* like a large and clustered variety of *O. congesta*, with *Modiola tenuisculpta*.

Dakota sandstone.

A short distance further down the river, under fifteen feet of alluvial deposits, is shown seventeen feet of white soft false-bedded sandstone containing thin layers of dark coloured very plastic clay. Below this clay are two feet of lamellar hard brown sandstone, which is again underlaid by six feet of lead coloured soft unctuous clay in which, near the top, is a thin very irregular bed of impure lignite, much of which has been replaced by pyrite. This lignite is sometimes associated with nodules of ironstone which contain fragmentary remains of plants.

The sandstone and light gray clay extend for a mile or more down the river, the face of the hard band of brown sandstone being in one place quite rounded off and covered with longitudinal glacial scratches, but it is impossible to make out their exact direction as the blocks that formed the point of the band have all been more or less displaced.

Last Cretaceous outcrop

A short distance further down the stream, where an ancient lake terrace crosses the country and the river flows out to the lower plain from a valley seventy feet deep, and extends away to the north-east in a shallow winding channel, the underlying Cretaceous rocks are seen for the last time in descending the river.

The section here is as follows :—

	ft.	in.
Plastic stratified superficial clay	8	0
Unstratified clay with a few pebbles lying unconformably on, and filling the irregularities in the underlying rocks (till)	8	0
Fine white soft stratified Cretaceous sandstone	2	4

	ft.	in.
Dark gray sandy shale	2	2
Soft white and light yellow sandstone with intermingled beds of dark gray clay shale	5	6
White sand and dark gray clay shale thinly interbedded	3	0
Soft plastic dark gray clay shale	4	6
Thin band of small fragments of lignite	0	½
Hard lead gray clay shale weathering into rounded butte-like shapes	12	0

Lignite.

Partially imbedded in this shale was lying a considerable mass of lignite showing all the details of its woody structure. It consisted of the partially carbonised trunk of a large tree which had fallen and become imbedded in the shale. All the lignite seen on Swan River was of this character, nowhere having become compacted into regular seams. A specimen now in the Geological and Natural History Museum in Ottawa, collected by Mr. J. W. Spencer in 1874 on Swan River, is also of precisely the same character and has evidently been broken from a carbonised tree-trunk buried in the shale.

Age of sandstones.

The above sandstones and light gray shales differ considerably from the soft unctuous shales, limestones and marls that have been already recognized as belonging to the Niobrara-Benton subdivision of Meek and Hayden's typical Nebrasca section, and which have been together designated the Colorado group by Dr. C. A. White. They also undoubtedly underlie these shales and limestones. They therefore correspond, both in position, and to a certain extent in character, to the typical Dakota sandstones of Meek and Hayden. Very few fossils have been found in them, but those that are known, favour this view of their age, and the absence of all the species found to occur in the overlying beds, is suggestive of a difference in age.

The approximate elevation of these beds where last seen is 150 feet above Swan Lake, where the Devonian limestone occurs in many places.

Rolling River.

Let us now examine the banks of Rolling River, which flows into the Swan River four miles below the last-mentioned exposure of Dakota sandstone, and which, with its tributary the Favell River, drains a considerable area in the northern part of the Duck Mountain. The upper portion of the east branch of Favell River was not examined, but the west branch, and Rolling River in their upper portions, before they leave the mountain, show nothing but drift deposits, and in descending them it is not until these streams cut a deep gully through a high ridge lying some distance from the foot of the main escarpment of the mountain, and known to the Crees as Minitonas, or Isolated Hill, that the Cretaceous rocks are first seen.

Minitonas.

The Rolling River, where it reaches this hill, at a point two miles above the old location of the C. P. R., is 1,300 feet above the sea. The banks are 100 feet high and composed of slate grey mottled calcereous clay shale, holding remains of *Inoceramus problematicus, Ostrea congesta, Anchodus Shumardi* and *Cladocyclus occidentalis.* Forty feet at the bottom is soft and quite shaly, while the rock above becomes harder, more compact and much more calcareous. It breaks with an irregular fracture, is much jointed, and stands out as a bold vertical cliff overhanging the sloping bank of softer underlying shale.

Niobrara-Benton shale

For a mile northward from where this first exposure of shale is seen, both sides of the winding stream show alternate outcrops of dark bluish-gray friable clay shale similar to the lower portion of the first-mentioned outcrop, and from which, in several places, issue springs of clear cold water smelling very strongly of sulphuretted hydrogen and leaving a white coating of sulphur on stones or other objects over which they flow. The river is here bounded to the east by a bank 120 feet high. The lowest fifty feet consist of the dark gray clay shale just mentioned, above which twenty feet of the bank is hidden, being covered by land slides. The upper fifty feet consist of fine-grained stratified sand very similar in character to that seen on the banks of Swan River, a short distance below the mouth of Bear's Head River.

At this high bank the river turns sharply in a direction N. 65° W., to about half a mile beyond the crossing of the old location of the Canadian Pacific Railway, a distance in all of two miles and three-

Benton shale.

quarters. For a mile and a half, dark gray clay shale, similar to that already mentioned, crops out in low exposures close to the edge of the water, beyond which the banks for a long distance are composed entirely of boulder-clay and alluvial deposits. The lowest outcrop of Cretaceous rocks seen was at an approximate elevation of 1,200 feet.

Favell River.

On the west branch of Favell River where it flows round the eastern point of Minitcnas, the bed of the stream is at an elevation of 1,330 feet. It is flanked on the west by a bank sixty feet high of grey mottled calcareous Niobrara shale, containing fragments of fish remains, and of a long thin-shelled *Inoceramus*, probably *Inoceramus problematicus.* These beds are, undoubtedly, a continuation of the upper harder beds seen on Rolling River. Close at hand are several springs strongly impregnated with sulphuretted hydrogen.

The shale is here overlaid by ten feet of unstratified glacial till with striated boulders.

Rolling River.

Returning now to Rolling River at a point S. 25° E. from the mouth of Tamarack Creek, where the bed of the stream has an eleva-

tion of 1,050 feet, a band of Dakota sandstone crops out from the bottom of a high bank, and crossing the stream, makes a succession of little cascades. This band consists of hard brown thick-bedded quartzose sandstone, massive or lamellar and often made up of small concretions about the size of peas, which are finely shown on many of the weathered surfaces. The surfaces of the slabs are often beautifully ripple marked, and on the edges show false-bedding in layers of about four inches in thickness. They contain *Lingula subspatulata*, *Modiola tenuisculpta*, *Lamna Manitobensis*, and pieces of carbonised or pyritised wood. The band of hard sandstone is overlaid by a bed of soft white sandstone or incoherent sand. The whole outcrop is a continuation of that seen opposite to it on the Swan River, and, lying below the shales of Niobrara-Benton age, clearly represents some of the beds of the Dakota group. Dakota sandstone.

Below this outcrop the river was followed for a little more than a mile, and Cretaceous strata were not again seen, the banks being almost entirely covered with slides, but the same series doubtless occurs here, as has already been described on the Swan River.

In following the section of the rocks, as shown in the banks of Swan River and its tributaries, some of the more prominent surface features of the surrounding country have necessarily been omitted for the time, and it will now be necessary to mention some of the most important of these. Surface features.

As was stated in the beginning of the report, Swan River flows in the bottom of a wide preglacial valley averaging about 1,200 feet in depth, cut through the Cretaceous plateau of the Duck and Porcupine mountains. The exact age of the valley is uncertain, but it is not improbable that it was largely formed during the period when the South Saskatchewan gravels were deposited in the west, and it would therefore be of Pliocene age. During the glacial period the valley was ascended by a lobe of the great glacier of the Winnipeg basin, and after the retirement of this glacier, most of the lower portion of the valley was occupied by a wide bay of Lake Agassiz, and is now generally covered with lacustrine or alluvial sands or clays. Preglacial valley.

An old cart trail, that has been used by the Hudson's Bay Company for the greater part of the present century, runs down the valley from Fort Pelly to the marsh at its mouth, keeping for most of the distance on the north side of the river. From the ford, ten miles north-east of Fort Pelly, the trail ascends the north side of the immediate valley of Swan River, and enters the "Five Mile Woods," a grove of spruce and poplar in which the soil is generally a dark clay, composed almost entirely of the subjacent Creta- Cart trail. Five Mile Woods.

ceous shale. East of this is a sandy plain, extending for about three miles and a half, and scored with old buffalo trails. In its eastern portion, the soil is a coarse sand, but towards the west it contains a large amount of gravel and its surface is strewn with boulders of red-

Delta plain.

dish and greenish gneiss. This is clearly an old delta plain, and the conditions now existing are very similar to those found on the highest gravel plains on North Pine River, with which this corresponds more or less closely in altitude.

For the next mile and a half the trail winds through small poplar, growing on the gentle slope of the face of the old delta deposit, and then it crosses a gently undulating sandy plain for about six miles, beyond which is a belt of poplar in which the land falls about 100 feet. This poplar covered belt is locally known as the "Coast Ridge," and seems to represent the eroded face of another lacustral or delta deposit.

From the "Coast Ridge" to the "Square Plain" is a more or less open, and often sandy tract which extends up the south side of the river to beyond Bear's Head Creek. It was formed when the waters of Lake Agassiz washed the foot of the "Coast Ridge."

Square Plain.

Square Plain is a wide ridge of rounded water-worn gravel, rising about twenty-five feet above the swampy land to the east of it. In some places it is a quarter of a mile wide, and is composed of five distinct ridges separated by light hollows, representing slightly different stages of Lake Agassiz. North of Swan River it flattens out rapidly, and was not followed for more than three miles, while south of the river it sweeps round in a gentle curve to the east, for at least five miles, which was as far as it was followed in this direction. It is about 1,160 feet above the sea, as compared with the height of the bed of Rolling River at the crossing of the old Canadian Pacific Railway location, which is given by the railway survey as 1,180 feet. It is probably part of the same old shore line as the 1,151 feet ridge near the north-east angle of the Duck Mountain.

Low country.

For five miles north-east of the Square Plain the trail runs over level country consisting of belts of small poplar and low meadow land. At the above distance there is a light slope, on which an irregular ridge of barren sand dunes marks another shore line of the ancient lake.

For the rest of the distance to Oak Creek on the southern trail, extensive meadows are separated by little belts of poplar, while the northern trail runs through a forest of thick poplar for five miles, on a well rounded ridge of coarse gravel wooded with poplar and oak. This ridge appeared to be at about the same elevation as the Square Plain ridge, but the two were not definitely connected by survey.

Our camp was pitched for several days near the mouth of Oak Creek, on the grassy bottom land by Swan River. The valley is sixty feet deep, and its sloping grassy banks descend in two beautiful terraces to the water. From here the writer made a trip with horses round and over the north-eastern point of Duck Mountain, his course being marked in a dotted line on the map. Oak Creek.

Two miles below Oak Creek a distinct gravel ridge crosses the country, and for nine miles further in the same direction the "Great Meadows" extend. They are wide stretches of rich flat land, covered with a thick growth of long grass, separated by narrow irregular belts covered with willow, and small, sometimes large, poplar. A forest of heavy poplar is then entered, and the trail is cut through it for six miles to the ford over Swan River, on the north-west side of which the Hudson's Bay Company used to have a store-house. Great Meadows.

For the next six miles, the trail is on the south side of the river in heavy poplar, till a ford is reached, where the river has a sandy bed. The banks are here fifteen feet high, and consist of white or light yellow stratified alluvial sand, the north bank being steeply cut. About twenty-five paces back from this abrupt bank, and just to the east of the trail, is the site of an old trading post of the Hudson's Bay Company, which was moved in the early part of the century to its present position near the head of Shoal River. The country is very level, and the site is marked by six hollows or depressions, some of which were doubtless cellars, and two heaps of stones where chimneys formerly stood. Old Fort, H.B.C.

In a poplar grove between two and three miles further down the river, at the point indicated on the map, the old trading post of the North-west Company was said to have been situated, but the spot was not visited. This post, and in fact much of the Swan River valley, is described by Daniel Harmon in his Journal, as it was at the beginning of the present century, and it is also mentioned or described by David Thompson, Alexander McKenzie and others. Old Fort, N.-W. C.

Below this old trading post the river is skirted by groves of poplar, elm, ash and ash-leaved maple, while flat low lying meadows extend towards the lake.

Returning to the streams that flow from Duck Mountain northward into Swan River, Bear's Head Creek, where crossed on a level plain three miles and a half from its mouth, was thirty feet wide, and ran over a bed of pebbles. It was not followed further, and its course is mapped from the survey of the western boundary of Manitoba. Bear's Head Creek.

Rolling River was examined from a point a short distance west of the 101st meridian, where it is about 2,250 feet above the sea. Rolling River.

It is here a small stream in a valley fifteen feet deep, with a spruce swamp on both sides. Its bed is covered with boulders, and its channel is much obstructed by beaver-dams.

Pleistocene deposits.

A short distance lower down it flows in a deep valley, the sides of which show some excellent sections of Pleistocene deposits.

One of these sections on the north bank is as follows:—

	ft.	in.
Stratified gravel	10?	0
Unstratified till with striated pebbles	22	0
Stratified sandy clay, becoming almost a pure laminated clay at bottom, where it contains many plants and fresh-water shells such as *Taxus baccata*, *Elodea Canadensis*, *Vallisneria?*, *Navicula lata*, *Encyonema prostratum*, *Denticula lauta*, *Licmophora?*, *Cocconeis*; *Lymnæa catascopium?*, *Valvata tricarinata* and a keelless variety, *Amnicola porata?*, *Planorbis parvus?*, *P. bicarinatus*, *Pisidium abditum* and *Spherium striatinum*	6	0
Stratified gray sandy clay	20	0
Slightly sandy stratified clay, coloured dark brown with bituminous matter, and containing a few small bivalves	1	10
Plastic clay	5	0
Coarse stratified sand	12	0
Covered to water	12	0
	88	10

Heart Hill.

A quarter of a mile further down the river, near what is called "Heart Hill," a scarped bank 150 feet high shows a very similar section. The upper forty feet consist of unstratified till holding many pebbles and boulders of gneiss, quartzite, mica-schist, ironstone, &c., with scratched and polished pebbles and boulders of limestone. This is underlaid by seventy feet of stratified clay, sand and gravel, below which forty feet of the bank is covered with slides. The bed of the river is here about 1,800 feet above the sea, and, falling from the overlying till are many fragments of Niobrara shale, which have been shoved up by the glacier out of Swan River valley to the north.

Terrace.

For three-quarters of a mile below this interesting exposure, the valley has a well marked terrace forty feet above the bottom land, and then a moraine nearly half a mile wide crosses the valley. It consists of rounded hills covered with boulders separated by small inclosed basins. This moraine appears to have blocked the river for a time and permitted the formation of the terrace just mentioned, but the stream now flows in an irregular channel through it. The moraine was not followed beyond the valley, and its extent was therefore not determined, but it would appear to have been formed

Moraine.

near the close of the glacial period, by a small glacier flowing northward or westward from a névé on the summit of the Duck Mountain, after the great glacier of the Winnipeg basin had receded, and sufficient time had elapsed to allow for the excavation of the main valley of Rolling River.

Below the moraine the wide and often open valley continues westward for about three miles till it is joined by Round Lake Creek, also flowing in an old wide valley, one branch of which is said to be continuous with the upper valley of Shell River.

Here Rolling River turns northward and follows the bottom of a deep, thickly wooded valley to the northern face of Duck Mountain. At the mouth of this valley is an extensive gravel plain through which the river now winds in a channel from thirty to forty feet in depth. This plain is between 1,400 and 1,500 feet above the sea, or about the same height as the highest sand and gravel plain seen on Swan River, and the two were probably formed at the same period. The gravel underlying this one is often very coarse, and was washed out of the till when the deep valley of Rolling River was being rapidly excavated. Deep valley. Delta plain.

Below this plain the river has been for the most part already described in connection with the sections of the Cretaceous rocks. At its lowest crossing, a short distance above the mouth of Favell River, it flows through a level country in a valley a quarter of a mile wide and sixty feet deep. At the bottom of the bank are exposures of Dakota sandstone, while above it are beds of stratified lacustral sand and clay.

Favell River also rises on the summit of Duck Mountain. Its east branch was not followed, but the source of the west branch is not far from the source of Rolling River, among rugged morainic hills covered with boulders and supporting only a scanty growth of small Banksian pine. It then enters a more even country wooded with spruce and poplar, and turning northward flows through a deep narrow valley to the northern face of the mountain. No sign of the underlying Cretaceous rocks were thus far seen, but where the bed of the river is about 1,800 feet above the sea a steep cliff shows at the top 100 feet of light gray unstratified till with striated pebbles and boulders, below which sixty feet are covered with slides. Favell River.

From the foot of the mountain the river flows in a shallow channel across a heavily wooded plain for three miles, till it reaches the south side of Minitonas Hill, where it turns to the north-east and cuts through the hill, exposing some good sections of Niobrara shales.

Near its mouth, where the stream is about eight feet wide, it cuts through a well-marked gravel ridge with an altitude of about 1,030 feet

above the sea. This ridge was also followed across the east branch and for some distance into the country to the east.

East of Favell River the country was traversed on the dotted lines laid down on the map to the north-east point of Duck Mountain, and was found to be very level throughout, consisting, close to the mountain, of spruce and tamarack swamps, and further north of meadows and poplar forest.

PORCUPINE MOUNTAIN.

Position. The Swan River valley is bounded to the north by the dark heavily wooded slopes of Porcupine Mountain, the streams from which, uniting to form Woody River, flow independently into the west side of Swan Lake. The most of this country was not personally examined but is mapped from sketches and triangulations made in the valley below, and from information received from native Indians or half-breeds. However, the trail from the mouth of Birch River to Kematch River was explored, and the valley of this stream was followed for a short distance.

Birch River. Birch River flows into the west side of Swan Lake at the end of a long alluvial point, where it is thirty-five feet wide and five feet deep without current. Its banks are wooded with elm and oak, but a low meadow-land stretches away on both sides.

Bridle trail. Starting at a point seven miles above the mouth of Birch River, the bridle trail strikes first westward and then southward across a level country without boulders, at first partly open, and afterwards wooded with large poplar. Ponds of saline (alkaline) water were occasionally found in some of the more open places, probably marking the line of outcrop of the Dakota sandstone at the base of the Cretaceous series. The trail crosses several small streams and then reaches an open ridge ten to twelve feet high and 500 wide running north and south. The ridge is a well rounded beach of Lake Agassiz with an approximate elevation of 1,125 feet above the sea, and is composed entirely of reddish quartz sand.

Kematch River. Kematch River cuts a valley fifty feet deep through this ridge. The bed of the river is thirty feet wide, but towards the end of August the stream was only twelve feet wide and six inches deep. The bars are scattered with pebbles and cobbles of limestone, gneiss, ironstone and light gray Niobrara shale. At the foot of the bank is a low outcrop of hard bluish brown-weathering sandstone, doubtless belonging to the Dakota formation, overlaid by ten feet of dark slate-gray clay shale, breaking into minute flakes, and weathering to a soft mud.

These shales are very typical of the Benton formation and here represent its base.

From the ridge, the course of the river was followed on foot for two miles to the face of the escarpment of Porcupine Mountain, where it flows out of a deep valley, from half to three-quarters of a mile in width. A number of low exposures of Benton shale may be seen during this distance, but the banks are generally composed of pebbles and small boulders, resting on a light gray till. The stream is overhung by gigantic balsam-poplars. Escarpment.

At the foot of the mountain the side of the valley is very steep and 140 feet high, but so overgrown with vegetation that the underlying rock could not be seen.

When returning to the bridle trail at the ridge, a course was taken south of the river. It first led down a steep slope sixty feet high on the face of the escarpment, then across a plain half a mile wide, and down another slope fifty feet high, at the foot of which was a flowing spring of clear water, tasting quite strongly of sulphuretted hydrogen. These escarpments represent ancient coast cliffs on the shore of Lake Agassiz, when the waters washed against their bases. The approximate elevations of these two shore lines would be about 1,270 and 1,200 feet above the sea respectively. Between the escarpment and the trail, much of the country is thickly wooded with large spruce, and another sand ridge is crossed with an elevation of 1,150 feet, on which is a grove of small oak trees. All this country is a famous hunting ground, and was everywhere beaten with fresh tracks of moose. Coast cliffs.

Further northward the face of the escarpment becomes higher and more abrupt, and the gorge from which Bell River flows can be clearly seen from Swan Lake as a deep notch in the brow of the dark green mountain.

Mr. Dowling travelled on a footpath from the mouth of Birch River to the summit of the mountain beside this gap and gives the following description of the country passed over:—

"The trail leading from Swan Lake starts just west of the mouth of Birch River and follows a small creek coming from near the foot of the mountain. At the lake, a fringe of poplar about a mile wide is growing on the eastward slope, but this is succeeded by level land somewhat swampy, on which some spruce is occasionally seen. The rise for some distance, however, is very slight, and at seven miles from the lake the altitude is 1,000 feet above the sea, or 145 feet above Swan Lake. From there, however, after passing an apparently level mossy swamp, the rise is more abrupt, and beyond a patch of burnt Trail to Bell River.

Bell River.

country on the surface of which are seen many large boulders of gneiss and limestone, the trail leads over several very distinct gravel ridges, forming an ascending series varying in elevation from 1,207 to 1,300 feet above the sea. These occupy a belt extending along the foot of the mountain, which, where crossed, is open, bearing only a few trees, principally jack pine (*Pinus Banksiana*). The trail deflects to the north, and leaving the gravel plain gains a somewhat level terrace, the steep face of which is strewn with boulders and the surface clothed with scrub poplar. The elevation of this terrace is about 1,400 feet above the sea, and in character it is very similar to the upper delta plain of the Swan River valley. Through it, the Bell River has cut a valley more than fifty feet deep, which seems to expose nothing but drift material.

The first exposure in this valley is above this delta plain, at an elevation of 1,450 feet above the sea. It is on the north side of the river, where a somewhat slidden hillside shows, to a height of thirty feet, a scarped face of dark gray clay shale. Thirty-five feet higher up

Pierre shales.

the bank and on the south side of the river, is an outcrop of light gray hard siliceous clay shale, associated with a few dark pebbles of ironstone. These shales were found by Dr. Rüst to contain the following species of Radiolaria:—

Caryosphæra æquidistans. Cenellipsis hexagonalis. Prunulum calococcus. Cyrtocalpis crassitestata. Dictyocephalus microstoma. Dictyocephalus macrostoma. Theocampe sphærocephala. Tricolocapsa salva. Tricolocapsa thoracica. Tricolocapsa Dowlingi. Tricolocapsa Selwyni. Dictyomitra Canadensis. Dictyomitra polypora. Dictyomitra multicostata. Stichocapsa Tyrrelli. Stichocapsa Dawsoni.

Pleistocene deposits.

"Above this, no rock in place was seen, and on the upper part of the valley the immediate banks show a few escarpments of light clay containing sand, pebbles and small pieces of light gray shale. The whole is partly stratified. Above the valley on the edge of the escarpment of the mountain, dark clay mixed with shale is overlaid by sandy clay, probably a mantle of drift material covering the mountain. The [illegible] viewed from the edge of the mountain is seen to be rough, small [illegible] appear scattered in all directions. The surface is dotted with boulders, and the bed of the stream is a mass of boulders of all sizes."

The remainder of the eastern and the northern slopes of Porcupine Mountain were mapped from sketches and triangulations made on Swan Lake, Dawson Bay, Rice River, and Red Deer Lake and river, and the hydrography of the interior of its summit is dotted in from sketches obtained from John Beardy, Kematch, and Peter Moore, three Indians living on Shoal River. They also informed me that the summit is generally rough and uneven, probably morainic, and is wooded

with small spruce and Banksian pine, like many of the higher portions of Duck Mountain.

RED DEER RIVER.

North of Porcupine Mountain, lying between it and Pasquia Mountain, is another great valley similar to, but even more extensive than Swan River valley. It is almost entirely drained by Red Deer River, though Overflowing River occupies much the same position in this valley, that Woody River occupies in the Swan River valley. Wide valley.

At th mouth of Red Deer River, where it flows into Red Deer Lake, a small band of Indians make their headquarters. From these Indians horses were obtained, and a trail was explored from the south-west corner of the lake to the Smoking Tent, and thence westward to the mouth of the Etoimami River, whence another old trail was followed down the north bank of the river to its mouth. A brief description of this route will convey the best idea of the general character of the valley. Indian camp.

The trail leaves the lake just west of an old winter trading post of the Hudson's Bay Company, and runs for nine miles over almost level country through a forest of large poplar and spruce, with open grassy glades, to Swampy Creek, a tributary of Armitt River. This creek is ten feet wide, with a channel two feet deep, in which only a few inches of clear water was flowing in September, 1889. The banks are of sand and fine gravel. The creek flows from what appears to be a deep gap in the northern face of the mountain. Porcupine Mountain trail.

A mile and a half south-west of this creek the trail crosses a well-marked gravel ridge which rises ten feet above the surrounding land and has an elevation of 1,100 feet above the sea. For the next two miles and a quarter the course is through belts of spruce and poplar and open meadows to Armitt River, which is here a beautiful clear stream flowing in a channel five feet deep, in the bottom of a valley fifty feet deep, over a bed of rounded pebbles of gneiss, limestone and Niobrara shale. Armitt River.

200 yards below the crossing, on the west side of the river, is a scarped bank fifty feet high, showing at the top six feet of clay with striated pebbles, probably till. The rest of the bank is a series of slides, but on the face of one of the slides, close to the edge of the water, is twelve feet of dark gray fissile Benton shale, and a few yards further down the stream are many large masses of white Dakota sandstone, holding carbonized impressions of plants, &c. The height of the bed of the river at this point is 1,090 feet above the sea. Benton shale.

Sandy plain.

From here the trail ascends the west bank of the valley and strikes southward through open pine woods, on a sandy plain with a mean elevation of 1,180 feet above the sea, to a well rounded ridge, with an elevation of 1,230 feet above the sea, on which it turns to the west.

Between the trail crossing and the ridge, a distance of about one mile and three-quarters, the bottom of the valley was also followed, and some good exposures of the Cretaceous beds were measured.

Niobrara shale.

A mile and a quarter above the crossing a steep cliff rises on the east bank of the river, showing at the top eight feet of light gray till with limestone pebbles, underlaid by thirty-two feet of dark gray soft fissile Cretaceous clay shale, in which there is a narrow band of soft white clay.

A third of a mile further up the river, and a short distance below the main gravel ridge followed by the trail, is a high bank of dark shale. In this bank, ten feet above the water, is a thin nodular band of light gray mottled calcareous Niobrara shale, containing many foraminifera, with prisms of *Inoceramus* and fragments of fish skeletons.

At the ridge, the river is beginning to be much obstructed with boulders, and the banks southward to the mountain seem to be generally low, while the surrounding country is chiefly timbered with poplar, and is probably crossed by other low ridges.

Gravel ridge.

The ridge followed is composed of sand and fine gravel, is generally raised from six to ten feet above the surrounding wooded or marshy country, and is wooded with a thin growth of small aspen. The trail runs along its summit for ten miles, in which distance it is cut across by several brooks, which do not expose sections of any particular interest. At Bushy Creek the trail forks, one branch turning northward towards Red Deer River, while the other branch, which was the one followed, turns southward across a level country to another wooded ridge twenty feet higher than the last, and then westward along this ridge for more than a mile to Smoking Tent Creek, which flows in a valley 300 feet wide and twenty-five feet deep. Its bed is twenty-five feet wide, and covered with rounded gravel. Half a mile west of the ford and close to where the creek first strikes the ridge, is a small open prairie locally known to the Indians as the

Smoking Tent

"Smoking Tent," where they are accustomed to camp from time to time. The point is close to the extreme western limit of the area covered by the accompanying map, and from it a direct trail is stated to run to Fort Pelly.

West of this place, the trail, back to the upper Red Deer River, continues on the ridge for two-thirds of a mile and then turns to the lower ridge, which it follows for between seven and eight miles,

to the west end of a long meadow which skirts its upper side. The trail then turns southward for more than a mile to a small open prairie, on another ridge which is clearly the continuation of the Smoking Tent beach. This ridge is generally composed of fine gravel, is about 125 paces wide, and is raised ten feet above the surrounding country. It was followed for between six and seven miles, as it curves gently towards the north, till about a mile past a point where it is joined by a good pack trail from Fort Pelly, it becomes indefinite and merges into a wide sandy plain dotted with sand dunes lightly wooded with Banksian pine. Here we turned north-eastward, and crossing the sandy plain for a mile and a third, reached the Red Deer River in a valley thirty feet in depth. Extensive delta plain.

The channel is 250 feet wide, but the water at the time was not half that width, and was flowing over and through a bed of large boulders of gneiss and limestone. The banks at the bottom are composed of light gray unstratified till, holding pebbles and many large boulders similar to those in the river, while above is a reddish stratified sand. The sandy plain was clearly formed by a river which flowed into Lake Agassiz when its waters stood at the height of the Smoking Tent beach, but its exact correspondence in age to other delta plains on the west side of Lake Agassiz has not yet been determined.

Two miles further upstream Fir River (O-kik-kan-tago Sibi) joins the Red Deer River from the north, draining the southern face of the Pasquia Mountain. It is thirty feet wide, with water from bank to bank, and its bed, like that of the main river, is covered with boulders. Its mouth is fifteen miles west of the accompanying map, in north latitude 52° 50′ and approximate west longitude 102° 24″. Fir River.

Just below it the bank of the river is forty-five feet in height, and consists at the top of twelve feet of light red horizontally stratified sand, underlaid by a few feet of gravel. The rest of the bank is covered with debris but springs are flowing from its foot, and it is therefore probable that it is in great part composed of stratified deposits.

A short distance further down stream is the mouth of the North Etoimami or Shallow River (Ka-pa-kwa Sibi), which was ascended by Professor Macoun in his trip from Red Deer to Swan River in 1881. At its mouth it is about 100 feet wide, with a bed of large boulders, over which little or no water was flowing in September, 1889. A cliff of light gray till twelve feet in height overhangs its western bank, and on a magnetic bearing N. 55° E. from this cliff, on the bottom land on the north side of Red Deer River, are the chimneys and cellars of two old houses that were formerly occupied as a trading post by the North-west or Hudson's Bay Company. North Etoimami River.

Trail north of Red Deer River.

From the mouth of Fir River a bridle trail, often very obscure, was followed down the north side of Red Deer River to within seven miles of its mouth.

The first mile is across a sandy plain wooded with Banksian pine, and the next six miles are over level or gently sloping country wooded with poplar or studded with small dead spruce. At the end of this distance, near the mouth of Spring Creek, the river is moderately deep, with an easy current, and the banks are composed of stratified sand or till. A large boulder of white Dakota sandstone is here lying in the bed of the stream. Its surface is pitted with holes caused by the decay of nodules of pyrites and in them the Indians put small offerings of bullets, shot, &c. The boulder is twenty-five feet long, sixteen feet wide, and rises three feet above the surface of the water. Its angles are well rounded off, and its upper surface is clearly marked by a number of elongated dints, often running into irregularly disrupted gouges, parallel to the river, and evidently made by the spring ice or stones, &c., borne along by it. But these markings are quite distinct from a series of long continuous nearly parallel gouges or scratches, which cover the whole upper surface of the boulder, running parallel to its greatest length, and which have been quite clearly formed under the influence of glacier ice.

Boulder of Dakota sandstone.

The river at this point is about 1,100 feet above the sea, and the boulder has been carried up the valley, by a westward flowing lobe of the great glacier of the Winnipeg basin, from the beds of the Dakota sandstone which outcrop twenty miles further to the north-east, and at from 100 to 200 feet lower level.

From Spring Creek to opposite the mouth of Smoking Tent Creek, close to the western edge of the map, the trail keeps near the river, often on its alluvial flats, and the banks were found to consist entirely of superficial stratified sand, &c., or glacial till.

Ash-leaved maple.

Opposite Smoking Tent Creek is a fine grove of large ash-leaved maple, close to which is a sandy plain by the river, where the Indians camp when they come in the spring to make maple sugar. Leaf Lake (Was-ki-té-poo Sakàhigan) on Overflowing River, was stated by an Indian who accompanied me, to lie immediately to the northward, and sufficiently close that in favourable weather in winter, a gun fired on the lake could be heard here.

For nine miles below the sugar bush the river continues to flow in a north-easterly direction, between banks overhung with elm and maple, while a poplar forest stretches away on either side. The banks generally consist of till with boulders, often overlaid by stratified alluvial clay.

Banks of till.

The river then bends to the east, and at the bottom of the bank light green Dakota sandstone appears for the first time. The section here exposed is as follows :— Dakota sandstone.

	ft.	in.
Unstratified till in the form of light gray hard sandy clay, with many striated pebbles and small boulders of gneiss and limestone, with a few of iron pyrites	17	0
Covered	22	0
Soft green clayey sand	1	0
Horizontal green Dakota sandstone	1	6
	41	6

This sandstone is very similar to that seen at the crossing of Armitt River, but here it was found to contain some pyritised wood, with teeth and bones of fishes, and a small species of *Lingula*.

Below this sandstone the river turns to the south, and a deep abandoned valley continues to the east, which is entered again by the river two miles further down. The valley is here seventy feet deep, and the banks consist chiefly of light gray till. For a mile and a half further eastward the trail runs across a sandy plain dotted with sand dunes, and at the end of the distance the bank of the river shows at the bottom five feet of soft brown or red Dakota sandstone, in places clearly false-bedded. It includes some thin bands of black clay, as well as many pebbles? of a clayey sand holding remains of plants. This is overlaid by fourteen feet of soft white evenly-bedded sandstone, and this again by light gray till with striated boulders. Abandoned valley.

For the next three miles the valley is deep, and the white Dakota sandstone outcrops here and there along its sides.

To within half a mile of the lowest outcrop of this sandstone, Mr. Dowling made a micrometer and compass survey of the river from the lake upwards in 1888, but there further ascent of the river with canoes became impracticable at the then stage of the water.

From this point the trail descends through woods of small poplar into a grove of beautiful tall spruce, and then through poplar, elm and maple to the river at its most northerly point, where its bank rises in an abrupt cliff of till thirty feet high. Our course then passed through woods of elm, poplar, maple and willows to the next bend of the river, where there is a patch of ground that had clearly been tilled long ago, and is now overgrown with golden rod, beyond which the trail follows the bank of the river on a beautiful grassy plain to the site of the Old Fort of the North-west Company. Thick woods.

This fort had a pleasing situation on a level alluvial plain, in front of which the river, with a width of 250 feet, flows in a channel fifteen feet Old Fort, N.-W. C.

Old Fort, N.-W. Co.

in depth. Just on top of the steep bank, and almost ready to be carried away by the first flood, is a heap of earth and stones, representing a chimney of one of the old houses, while all the others seem to have been already carried away. Several small depressions in the vicinity may, however, represent old cellars or holes in which potatoes were stored.

Standing with his face towards the river the writer looked across to a lovely forest of elm and maple, just tinted with brilliant autumn colours, while to the right were groves of maple and willow, and to the left was a forest of poplar pinnacled with spires of dark green spruce.

At the beginning of the present century this place was an important trading establishment of the North-west Company, being mentioned by Sir Alexander Mackenzie as one of the three chief trading posts of the Lake Manitoba district. From it a cart trail is locally reported to have led up the north side of the river to the western plains, but no trace of such a trail can now be seen.

A mile and a half below this old fort the trail crosses the river, where a fine grove of large ash-leaved maples is growing near the southern bank. A mile further down stream the remains of an old fort of the Hudson Bay Company are to be seen within a heavy poplar forest.

Old Fort, H. B. Co.

For the rest of the distance to its mouth, the banks of the river are low, and stretch back to extensive meadows covered with rank grass.

DUCK MOUNTAIN.

Position and extent.

Duck Mountain is an elevated table land or extended ridge rising in some places to 1,900 feet above Lake Winnipeg or 2,600 feet above the sea. It is bounded on the north by a wide sloping valley, down the centre of which Swan River flows into Swan Lake, and thence by Shoal River into Lake Winnipegosis. To the north of this valley the Porcupine Mountain rises apparently to a height equal to that of Duck Mountain, while in the middle of the valley, Thunder or Bird Hill rises 500 feet above the plain at its base, having been left as an outlier by the denuding agencies that carved out the valley from the once continuous plateau. Towards the east the mountain is bounded by the Manitoba escarpment sloping down into a wide depression, the bottom of which is occupied by Lakes Winnipeg, Winnipegosis, Manitoba and a number of small surrounding lakes. Towards the west the mountain slopes off much more gradually to the valley of the Assini-

boine River, the head of which at Fort Pelly is 650 feet above the level of Lake Winnipeg. Towards the south it merges into the Riding Mountain, being separated from it merely by the valley of Short Creek, which towards the east opens out into the wide funnel-shaped valley drained by Valley River.

Drainage.

The eastern face of the mountain is drained by several small streams that flow into Lakes Winnipegosis and Dauphin, most of which, however, rise below the summit of the escarpment. A belt along the north side of the mountain is drained by streams that flow northward into Swan River. The greater portion of the area of the surface, however, is unwatered by the Valley and Shell rivers, which flow parallel to each other southward for a considerable distance and then diverge, one to flow eastward into Dauphin Lake, and the other, after flowing westward for six miles, to again turn southward to join the Assiniboine River. West of Shell River several small streams drain the country south-westward into the Assiniboine River. Very few of the streams show signs of the underlying Cretaceous rocks, the country being generally thickly covered with drift deposits, but it is quite probable that in some cases the valleys of the streams are cut down to a much greater depth than the thickness of this superficial covering of drift.

Rough hills.

East of Shell River the Duck Mountain is generally very rough and uneven, consisting of ridges, and apparently irregular areas, of drift hills thickly covered with gneissoid boulders, often bearing a scanty growth of Banksian pine, between which are extensive areas of comparatively level marshy land densely overgrown with spruce and tamarack. The southern portion of this district is drained southward into Valley River, part of the central portion westward into Shell River, while the northern portion is drained either northward into the Rolling and Favell rivers or eastward into the Duck and Pine rivers.

Head of Valley River.

The source of Valley River was not visited, but Indians who were hunting in the vicinity reported that it rose in Singoosh or Weasel Lake and flowed south-westward to Angling Lakes. Another small branch of this stream was, however, found to rise in a wide swampy level country covered with spruce and tamarack, and probably underlaid by alluvial or lake deposits. The small creek, flowing from this swampy area towards the south-west, soon cuts through a ridge of irregularly rounded hills running in a north-westerly and south-easterly direction. These hills are thickly overstrewn with boulders and separated by basin-shaped depressions, and have all the appearance of being an old moraine. After flowing through this morainic ridge, the creek enters a wide valley. The bottom is swampy and covered with willow or spruce. The south side is a continuation of the high ridge that extends east-

ward to Manitowachi, while the north side rises in beautiful gravel terraces to what appears to be an alluvial or flood-plain of considerable extent. Continuing towards the south-west for two miles, and then turning north-westward for about three miles, this small creek joins the main stream of Valley River.

South of the river is a rough morainic tract rather thickly timbered with spruce, birch and poplar. West of this morainic area a more or less level district stretches for several miles, in the bottom of which lie several small lakes known to the Indians as the Angling Lakes. Near these are a number of well built log houses in which Côté and his band of Saulteux live during the winter season, while hunting and trapping in the neighbouring forests.

Angling Lakes

Following the cart-trail westward from these lakes an area of rich meadow land is passed over, consisting of wide swails separated by long low ridges. The surface consists of sand and rounded water-worn gravel, the latter chiefly composing the low ridges on one of which the Indian houses are built.

Indian cart-trail.

About two miles west of the village the trail crosses a ridge of rounded knob-like morainic hills scattered over with gneissoid boulders. Beyond this again is a lightly rolling country generally thickly timbered with large aspen and dotted here and there with small marshes. In the middle of this district the trail crosses the north end of a wide valley, the bottom and sides of which are covered with sand and gravel, no boulders being seen on the surface. The south side is open and grassy and rises in regular terraces, the surface of which in many places, however, are not at all level, but show low knobs and basin-shaped depressions, very much like the usual morainic contours, but it seems not impossible that the depressions may be caused by the unequal carrying away of the finer particles from among the gravel by underground drainage, and the consequent irregular sagging of the surface.

Wide valley.

Valleys of the Champlain or Terrace Epoch.

The most noticeable of these valleys is that of Shell River, its extreme northern portion being occupied by Rolling River. This valley runs in an almost due north and south direction through the centre of Duck Mountain. At the northern end it opens on the abrupt escarpment of the mountain into the wide valley of the Swan River and its tributaries, and at its southern end joins the valley of the Assiniboine. Its length measured in a straight line from one end to the other is sixty-seven miles, but counting its windings its total

Shell River valley.

Extent.

length is ninety-five miles. It has an average width from brim to brim of three-quarters of a mile or a little more, and its depth ranges from 100 feet at the mouth of the east branch to 365 feet at the trail crossing at Asossippi.

Slope.

As is shown by the present course of Shell River, the valley has a general slope towards the south. The height of the river flats at the mouth of the east branch is 2,050 feet above tide, and of the flats at Asessippi 1,450 feet above tide, giving a fall of 600 feet in seventy-five miles, or an average fall of eight feet to the mile. This fall is pretty evenly distributed throughout the whole of the above distance, though towards the mouth it is a little steeper than elsewhere. The north end of the valley for three miles is occupied by Rolling River, but, unlike that further south, is here thickly wooded with spruce and poplar, and it is much more difficult to see its salient features. About thirteen miles of the course of the valley was not followed, but looking up the north branch of Shell River it was seen to continue onward for several miles till a light bend cut off the view, and the bottom was filled from bank to bank by a deep marsh, in which the stream appeared to take its rise. Looking from Rolling River, it appears as a deep valley, down which flows a small tributary. A half-breed who was with me, and who was acquainted with the country, stated that this valley is a continuation of that of Shell River, and in it there is a marshy watershed.

Stream flowing northward

Beginning in latitude 51° 43′, a short distance above the confluence of the east branch, the valley is a mile wide and largely occupied by a beautiful even prairie lying on the east side of the river, and sloping very lightly towards the west. This prairie is underlaid by small rounded water-worn gravel, and represents a flood-plain of the ancient stream. Proceeding southward to the mouth of the east branch, which flows in a narrow lateral valley, the main valley is a mile wide, with an alluvial flat on the east side which is underlaid by a sandy loam, and partly covered with willows, while on the west side of the river a low sparsely wooded terrace half a mile in width extends along the foot of the bank. The Indians allege that at this point, huge bones were found at the bottom of a land-slide and were brought to the officer in charge at Fort Pelly, by whom they were forwarded to England. Hon. W. J. Christie, of Brockville, Ont., who was in charge of Fort Pelly at the time, informs me that the bones were shoulder blades, and that in 1853, some years after the first bones were brought in, he visited the place, "and examined the spot carefully where the blade was taken out of the river at low water. A land-slip had occurred from the bank and carried the bones into the river. I found from cross-questioning my

Shell River flowing southward.

Bones of Mastodon.

Bones of Mastodon.

guide, that the Indians had collected the bones, and burnt them on the bank, from superstition, and buried what would not burn. I examined the spot where they had buried the bones, but what remained crumbled to pieces when touched."

These bones, consisting of a pair of mutilated scapulæ of a fossil elephant, were submitted to Sir John Richardson for examination. He first described them as belonging to a new species which he named *Elephas Rupertianus*, but afterwards identified them as belonging probably to *Mastodon giganteus*. His descriptions are not generally known, and will be of interest here.

Description by Sir John Richardson.

"The scapulæ are right and left, and, being of the same size, were most likely members of the same individual. The broad ends of the blade in both are wanting, and mo of the spinal ridge. On comparing what remains with scapulæ from Eschscholtz Bay, and with the homologous bone of the *Elephas primigenius* in the British Museum, I find that these fragments differ in possessing a well-marked depression between the humeral end of the ridge and the anconal edge of the bone. This depression is 4½ inches long, and has an abrupt edge, upwards of an inch deep, next the spinal ridge, but gradually passes into the flat bone in other directions.

The length of the glenoid cavity is	9·1 inches.
Its breadth	5·5
The space between the depression and the f al edge of the bone where narrowest is	4·0
Length of the largest fragment	17·5

"The probability is that the Swan River (Swan River district) bones belonged to the *Mastodon giganteus*, and that the range of that species must be extended northward in Rupert's Land to the fifty-second parallel of latitude."*

For four miles below the mouth of the east branch the valley appears to be less definite, and being more or less wooded its characteristics are more difficult to make out in a running examination.

Valley deepens.

Turning south-south-eastward from the point where a pack-trail from Coté's Reserve crosses the river, the valley is moderately straight for seven miles, and its banks quickly increase to 200 feet in height. On the west side of the valley a terrace rises to the height of 100 feet, but its eastern face, instead of being abrupt, is sloping and grassy or dotted with a few scattered Banksian pines, the top of the terrace is covered

*The Zoology (of the) Voyage of H.M.S. Herald; Vertebrals, including Fossil Mammals, by Sir John Richardson, pp. 101-162 and 141-142, 4to, London, 1854.
Also Proc. Bost. Soc. Nat. Hist., Vol. 5, (1854) p. 82.
And Am. Jour. Sci., Vol. 19 (1855) pp. 131-2.

with spruce and poplar, the most of which has, however, been lately destroyed by fire.

Turning now towards the south-west for seven miles the valley shows a beautiful series of terraces reaching up on either side to near the tops of the banks, those on the north side being grassy and open, while those on the south side are covered with poplar. Close to the river the bottom of the valley is often wooded with spruce and tamarack. These terraces consist of water-worn gravel, the brows of the higher ones being scattered with boulders of gneiss. The lowest one is generally wide, and smooth, and reaches to near the bank of the stream. Terraces.

At the end of the above distance, the river sweeps round to the left and for ten miles flows in a south-easterly direction, at right angles to the course that it has just been following. A high gravel terrace runs round the outer side of the bend for a considerable distance, and before it is entirely cut away, it reappears as a beautiful wide open bench on the opposite side of the river. Throughout the whole of the distance that the river keeps this south-easterly course the banks are very regular, being composed entirely of high terraces, the upper one of which extends back a considerable distance to the higher land behind. Near the southern end of this straight stretch slight exposures of clay are seen in the banks on opposite sides of the valley, that on the east side, which was more closely examined, showing six feet of unstratified light gray sandy clay holding striated pebbles, overlaid by three feet of stratified water-worn gravel. Also in a gully at the bend of the stream a slide has very imperfectly exposed about thirty feet of light gray and yellowish clay and sand, the upper part being a fine slate gray clay, while below it is a yellowish slightly clayey sand. The face of the bank is covered with slidden pebbles, some almost round and others very irregular, of limestone much striated, quartzite occasionally striated, gneiss and ironstone. Till and gravel

Now turning at right angles the valley continues for seven miles in a south-westerly direction. It is wide and open, bending in long sweeping curves. The inner sides of the curves rise in many grass-covered gravel terraces to 120 feet above the river. The banks are moderately well defined, scored by small lateral gulleys, but are nowhere cut into rounded hills separated by deep basin-shaped depressions, as they are below the next bend. The brows and often the tops of the higher terraces are generally strewn with gneissoid boulders.

At the end of the course towards the south-west, the river again bends round to the left, and for eleven miles flows in a general direction S. 30° E. The character of the valley now suddenly changes. It is sometimes as much as two miles wide, and its banks are very irregular Uneven banks.

and from 200 to 300 feet high. At first, gravel flats and low terraces continue down the centre of the valley, and the sides are rough, or with a skirt of rough rounded hills under the brow of the main bank. In some places wide terraces stretch out towards the river, and deep "kettle-holes" are found in the otherwise level bench, beyond which again may be a ridge of rounded hills thickly covered with gneissoid boulders. Near the crossing of the north line of Township 26, the sides of the valley are fringed with these rounded hills. On the east side, the river cuts into one of them, and though the exposure is very largely hidden by slides, yet at the height of sixty feet above the water there can be seen eight feet of light yellowish-gray unstratified slightly sandy clay, holding pebbles of gneiss and limestone, the latter of which are all plainly striated. Springs of water are running from the bottom of the bank, and as the above described boulder-clay is seldom sufficiently porous to allow water to flow through it, it is probable that the Cretaceous shales may here be found under the boulder-clay and above the level of the bottom of the valley.

Moraine.

For a mile and a half further down the valley the river flows through a wide gravel plain, and then the rounded drift hills, thickly strewn with boulders, close in from both sides and choke the valley, the river cutting a comparatively narrow channel through them. Below this barrier the drift hills are confined to the east side of the river, and from their base a wide alluvial plain stretches across the valley, above which, on the west side, gravel terraces very soon begin to rise. The hilly country extends for a considerable distance back from the river towards the east. The river cuts into the side of one of the hills, and shows it to be composed of unstratified till, against which on both sides stratified river gravels are lying horizontally. This hilly ridge which has thus been seen to run very obliquely across the deep valley of Shell River would seem to be an old moraine left by the continental glacier in one of the later glacial periods, or by a lobe of it which occupied the valley of the Assiniboine.

From the south end of this course of the river, a narrow valley with its bottom occupied by small lakes or marshes, continues southward but drains northward into Shell River.

Short Creek.

Another deep narrow valley also turns off to the east, in which Short Creek begins to flow eastward to Valley River. It is at first clearly defined, with steep banks 150 feet high and about three-eighths of a mile apart on the top. The bottom is a marshy flat. Deep narrow gullies join it from both sides, out of one of which the creek takes its rise. A short distance west of this gully the sides of the valley have been washed down causing a dam which forms the watershed between

the waters flowing to the east and to the west. The lower part of the valley of Short Creek is wider and much more sloping, with banks cut into rounded knolls, and generally covered with gneissoid boulders. The difference between the two parts of the valley is very abrupt and striking, showing the eastern portion to be a much older drainage channel than the steep narrow portion further west. The newer part of the valley has probably been excavated by the waters of the upper Shell River, which found their way along the east side of the morainic ridge just described, and thence flowed eastward down Short Creek into the west side of Lake Agassiz.

Lower portion of river.

Turning westward from the point where these valleys join, Shell River flows almost due west for five miles, then south seventeen miles, and then north-west four miles to its mouth. The valley throughout this distance maintains very much the same character as before, except that it is generally wider and becomes much deeper towards its mouth. High terraces rise on either side, the upper one of which on the north side extends back one to two miles before the main bank is reached. At the bend towards the south the valley is two miles wide and on the inner side of the curve, gravel terraces rise to a height of 140 feet above the river. The brows of these terraces are, as before, often thickly strewn with large gneissoid boulders. About section 15, township 24, the valley is again more than a mile and a half wide and the east bank rises in five well-defined terraces, which are respectively about 30, 75, 125, 170 and 180 feet above the river. Above the top of these, the bank again rises 120 feet to the level of the surrounding country. In section 34, township 25, the highest gravel bench on the south-east side of the valley is 100 feet above the river and is thickly strewn with boulders. It differs from the terraces in most parts of the valley, however, in not having a level surface. Its middle line is the highest, and from this line it declines from ten to fifteen feet towards each side, in the one direction to the brow of the terrace, from which it descends sharply to the bench below, and in the opposite direction to abut sharply against the side of the valley, which rises high above it. This latter depression probably indicates an ancient channel of the river when the bottom of the valley was at the height of this terrace.

Five terraces.

Asessippi.

At Asessippi, where the river finally bends towards the north-west to join the Assiniboine, several well-defined terraces occupy the north side of the valley, the highest of which is 185 feet above the level of the river at the mill-dams. The top of the bank of the valley on this side is 250 feet high, north of which, for several miles is a small area between the Shell and Assiniboine Rivers, covered

with alluvial sandy deposits, indicating the existence of a former lake at the junction of these two streams.

The south bank of the valley at Asessippi is more than 100 feet higher than the north bank, is very steep and largely covered with land-slides. As far as can be seen, it consists of unstratified glacial till, but it is not improbable that the bottom of the bank, if uncovered, would be found to be composed of Cretaceous shales.

A description has thus been given, in greater or less detail, of the principal one of these old glacial valleys cutting through the Duck Mountain. Between the Shell River and the Assiniboine, however, there is a plexus of similar valleys which was crossed in several places. It is now drained by the Little Boggy and Big Boggy creeks and a small brook flowing into Shell River.

Big Boggy Creek.

Big Boggy Creek, at the crossing of the Fort Pelly trail, is a small stream twelve feet wide and one foot deep, with a bed of rounded pebbles. Its valley is 180 feet deep. The north side is rough and uneven, its character being in all probability determined both by former terraces and old land-slides. On the south side a sandy flood-plain forms the top of the bank and lies only a few feet below the surrounding more irregular country. The next point where this valley was seen was in section 29, township 28, on the cart-trail from Côté's Reserve to Angling Lakes. The creek is here four feet wide and two feet deep, and flows through a very swampy bottom. The banks of the valley are 145 feet high and very abrupt. On the eastern side of the valley is a beautiful grassy flood-plain or terrace, underlaid by water-worn gravel, which stretches a long distance towards the south, and half a mile back from the brink of the valley. To the west the country is scattered over with boulders and is underlaid by a light coloured fine silt including pebbles. The boulders are especially numerous on the tops of the pointed knolls that lie along the face and summit of the escarpment which faces towards the west and overlooks the apparently level plain of the Assiniboine below. From the point where the Angling Lakes trail leaves the river, the valley continues in a northerly direction, and our guide stated that it united with that of Little Boggy Creek.

Little Boggy Creek.

At the crossing of the Port Pelly trail, Little Boggy Creek is a small stream fifteen feet wide and one foot and a half deep. It is thus seen to be much larger than the Big Boggy, the first adjectives referring rather to the amount of swamp on the banks of these little streams than to the size of the streams themselves. Two and a half miles east of the trail crossing, Little Boggy Creek flows from a wide valley about 200 feet deep at its mouth. Seven miles further

in a north-north-easterly direction, at the crossing of the western boundary of Manitoba, it is stated by J. P. O'Hanly to be 260 feet deep, and my half-breed guide also stated that it then turned south-eastward and joined a similar deep valley that carries a small stream into Shell River in Lat. 51° 31′. From the western mouth of the valley the Little Boggy now sweeps round towards the north, but the ancient stream would appear to have turned southward into a deep swampy valley, through which it found its way to the Assiniboine.

ASSINIBOINE RIVER.

Source.

The Assiniboine River rises near the head waters of Red Deer River, and flowing south-eastward, crosses the Second Initial Meridian close to Fort Pelly.

From here it was descended in a canoe by the writer in June, 1890, but as its valley has already been described by S. J. Dawson Prof. J. Macoun, Dr. R. Bell, and others, it will not be necessary to mention anything but its geology, and a few points in reference to its history as a trade route.

Descent in 1890.

Our boat, a small Osgoode canvas canoe, was put in the river in June, 1890, opposite Fort Pelly, and the river was descended to Portage la Prairie, thirty days being occupied on the trip.

Fort Pelly.

Fort Pelly is situated on rising sandy ground on the east side of the river, and is a large well-built fort protected by a high fence or wall of sawn planks. Over the heavy gate in front is a stout bastion, from the top of which a magnificent view can be had of the surrounding country. This fort was built by the Honourable W. J. Christie, Chief Factor of the Hudson's Bay Company, in 1856-57, while previous to that date the fort had stood on lower land 500 yards distant in a direction N. 65° W., where there is a low sandy ridge rising six feet above the general level of the bottom of the valley. The site of the old fort is now marked by ten pits in three rows, and a few small boulders.

Pierre shales.

Three miles in a direct line below Fort Pelly the west bank of the river is twenty-five feet high, and is thickly strewn with nodules of iron-stone and boulders of limestone and gneiss. The upper part of the bank is a dark gray till, below which is two feet of Lower Pierre (Millwood) shales, consisting of a brownish-gray soft clay shale, weathering into a soft light gray clay. This shale contains a number of light gray nodules of ferruginous limestone, but no traces of fossils could be found.

Boulder of Dakota sandstone.

At a fish-weir, a quarter of a mile further down the stream, a large spherical or hemispherical nodule of Dakota sandstone, like those out-

Boulder of Dakota sandstone.

cropping on Kettle Hill south of Swan Lake, is lying at the foot of the bank, having evidently fallen out of the till. The nearest point at which the Dakota sandstone outcrops is in the banks of Swan River not far from the mouth of Tamarack Creek, forty-two miles distant in a direction N. 50° E. and at an elevation of 1,025 feet above the sea. This formation is believed not to outcrop at a higher elevation than 1,125 feet above the sea anywhere on the whole face of the Manitoba escarpment. The place where the boulder is now lying has an approximate elevation of 1,475 feet or 450 feet above the nearest bed of parent rock, or 350 feet above any outcrop of the rock, for there is every reason to suppose that there are no exposures of the Dakota formation to the west of Fort Pelly until the disturbed strata in the vicinity of the Rocky Mountains are reached.

Its journey.

The boulder has therefore been carried up the Swan River valley in a south-westerly direction, for at least forty-two miles, by the Swan River lobe of the Winnipeg glacier, rising in the distance travelled at least 350 feet.

Alluvial banks.

From this point to the mouth of White Sand River the banks are generally stratified alluvial sand or clay, with here and there a slight exposure of Lower Pierre shales holding ironstone nodules. The river begins with a width of about fifty feet and a swift current, with sandy points stretching into the stream on the concave sides of the bends, and the channel much obstructed by snags and boulders, but it gradually increases to a width of 120 feet, becomes more sluggish, and the inner sides of the bends are rounded and covered with long-leaved willow.

White Sand River.

White Sand Creek is a stream thirty feet wide and three feet deep, with a perceptible current to its mouth.

From White Sand to Little Boggy Creek the river is generally deep with a sluggish current, and with a few slight rapids at the bends. The banks of the channel are ten to fifteen feet high, of alluvial clay, while the sloping banks of the valley are thinly scattered with boulders.

Little Boggy Creek, about fifteen feet wide, flows through a wide alluvial meadow to its mouth. Above this meadow it flows through a moderately level plain, with a mean elevation of 1,540 feet, rising

High terrace.

gently to the foot of a terrace along the base of Duck Mountain. North of Little Boggy Creek this latter terrace is a mile and a half wide, extends for a long distance to the north, and has a mean elevation of 1,700 feet above the sea. To the eastward, Duck Mountain rises as a long undulating slope, the nearest parts of which are only lightly wooded.

Crow's Stand.

From the upper terrace an elongated hill or ridge, known as the "Crow's Stand," rises abruptly to a height of 120 feet. This hill is

lenticular in shape and trends N. 25° W. and S. 25° E. Its north-west end and both sides are very steep, and its top is rounded, but may be said to be fifty feet wide. Its highest point is close to its north-west end, whence it slopes very gradually S. 25° E. for half a mile and then dips more rapidly to the general level. There are no cuts or breaks in the surface of this hill to show its true character, but its summit is sandy, and scattered with large boulders of gneiss and dolomite, while its sides are gravelly and its whole surface is too barren to grow any timber. It has therefore every appearance of being a drumlin or ridge of sand, gravel and boulders formed beneath the ice when this whole valley, stretching westward from the foot of the Duck Mountain, was filled with a glacier. Drumlin.

The terraces were then formed on the shore of the lake, elsewhere called Lake Assiniboine, that occupied this basin when the glacier withdrew from it. Throughout the whole of the way from Little Boggy Creek to Fort Pelly the cart-trail is on the bed of this ancient lake. Ancient lake.

Below Little Boggy Creek the valley of the Assiniboine River becomes deeper and more sharply defined, and its sides are generally wooded, while the bottom-land is either wooded or open. Scarped banks are occasionally seen, composed of Pierre shale with ironstone nodules, or gray till. Several spring creeks join the river from the east in this stretch.

About the middle of the east side of the S.W. $\frac{1}{4}$ section of Section 14, Township 28, Range 31, are the ruins of an old trading post of the North-west Company. It stood in the bottom of the valley 500 paces east of the river, and fifty paces from the foot of a wooded bank, at the mouth of a dry ravine, on lightly sloping land thirty-five feet above the river. The post was built by Mr. Cuthbert Grant, one of the traders of the North-west Company, previous to the close of the year 1793, and for many years did a large trade in beaver and otter.* Cuthbert Grant's house.

The fort or trading post appears to have covered about a quarter of an acre, in which area are six pits that doubtless represent the old cellars. Beside one of the largest is a heap of boulders that were formerly built into the fireplace of the largest of the houses.

A mile to the south of the old fort, the west bank of the valley is 240 feet high, on the top of which is a level sandy plain stretching out on both sides of the river. On the brow of the bank, a few boulders of gneiss are lying, while below it is a scarped bank forty feet high, apparently composed throughout of reddish sand with a few pebbles. Below Sandy banks.

* The Red River, by J. McDonell. L. R. Masson, Vol. I., pp. 275 285. Montreal, 1888.

this, the hillside is very rough and uneven, the banks, having fallen in a succession of slides, leaving small trough-like valleys above and behind each other. The surface of the slides are sand, but they are doubtless sliding on the soft Pierre shales.

Three miles further south on the east side of the river, a clear brook of cool water six feet wide and six inches deep flows from a wide open valley. The original bottom of this valley is about 120 feet above the bottom of the valley of the Assiniboine. Close to its mouth the brook has cut a V-shaped gorge down through this old bottom land, leaving rugged hills, on the top of which the old terrace can occasionally be detected. On the opposite side of the Assiniboine valley is a sloping terrace at about the same height.

V-shaped gorge.

Two miles further down the Assiniboine, a wide valley drained by a small stream known as "Two Creeks," joins the main valley from the north-west. The valley of the Assiniboine immediately changes its direction towards the south-east, assuming the direction of the valley of Two Creeks. At the same time it has more extensive bottom lands, and the stream which has been sluggish for a long distance, becomes somewhat more rapid. Elm trees are seen in the valley here for the first time.

Two Creeks.

The valley maintains the same character for ten miles, to the mouth of Big Boggy Creek. Many small rills flow down the slopes into the river, and bare slidden banks near the brim of the valley attest to the presence here of the bed of sand previously seen, from under which the rills probably have their sources. The Pierre shales were seen in very few places.

Many springs.

Big Boggy Creek at its mouth is thirteen feet wide and two feet deep with a current of a mile an hour. It flows from a wide valley, the bottom of which seems to be about fifty feet above the level of this river, but like the stream described above, it has cut a narrow V-shaped gorge in the old floor of this valley in descending to its mouth.

Big Boggy Creek.

Below the mouth of Big Boggy Creek the river turns again to the south. It is 100 to 120 feet wide and flows with an easy current. The east side of the valley is generally wooded, while the west side is often bare, or dotted with groves of small poplars. The banks of the channel consist of alluvial sand, but at a few of the outer bends large boulders give evidence of the presence of till, and nodules of ironstone show that the Pierre shales are not far away.

Just south of the middle of Township 25, Range 29, where the valley is 240 feet deep, the higher parts of the east bank show some interesting exposures of till and stratified sands, &c. At one point, below three feet of stratified sand at the surface, are fourteen feet of brownish-gray

Upper and lower till.

unstratified till, holding a number of boulders of gneiss and limestone, many of which are striated by glacier action. In another section twenty-five feet of till were shown. The upper six feet are here separated by a distinguishable colour-line from the lower. Along this line most of the boulders are lying, and in one place the two tills are separated by a thin lenticular bed of sand and gravel. It is also interesting to note that the boulders are all smoothed and striated on the upper surface, while many of them are otherwise rough. The boulders are imbedded for the greater part of their depth in the lower harder till, and when they are undisturbed the striæ appear to trend in a constant direction, viz., S. 75°—80° E.

Pavement of striated boulders.

A similar observation was made on boulders imbedded in the surface of the till near the bank of Silver Creek, a mile east of Binscarth. The place was a borrow-pit north of the railway track, in which many boulders were lying about. All of these were seen to be well polished and striated on one side. Twelve boulders were found in place in the till, and in all the upper surfaces were smoothed, striated and horizontal. The striæ were parallel throughout, trending S. 45° — 55° E. They had the same character, and had clearly been formed in the same way, as the striæ on the limestone surfaces around the great lakes to the north-east. The whole surface of the older till had been passed over by the glacier of the Assiniboine valley moving south-eastward, and the hard boulders had retained the striæ.

Boulders at Silver Creek.

From the above point to the mouth of Shell River the river is from 150 to 200 feet wide, with a very easy current. The banks of its channel are six to ten feet high and composed of stratified alluvial deposits. Wide grassy bottom lands with occasional groves of elm extend across the valley, whose sides are generally also grassy or dotted with groves of poplar in the little ravines. Some nodules of ironstone with a few crystals of selenite are lying on the slopes, having been weathered out of the underlying Pierre shales.

Sloping valley

Shell River flows with a swift current out of a wide V-shaped valley, and across a level flat through a beautiful grove of large elms.

From the mouth of Shell River to the village of Shellmouth the river is rapid; sand and gravel bars stretch out from the points into the stream. In places a wide meadow land fills the bottom of the valley, and in other places a terrace thirty feet above the river skirts its banks to the north. This is the first terrace seen in the valley since leaving the mouth of Little Boggy Creek.

Rapids.

In this piece of river an old location of the Canadian Pacific Railway crosses the valley, the bottom of which is stated upon the profile to be 1,335 feet above the sea.

Old C.P.R.

Shellmouth.

The small village of Shellmouth is situated on the east side of the river, where five beautiful open terraces form a series of steps up the side of the valley.

The country on the top of the bank, about 230 feet above the river, is level and underlaid by sand and gravel with a few boulders, which latter are found in greatest number along the brow of the hill. Here a few stunted oaks are growing. Descending a scrubby slope for 100 feet, a sandy terrace is reached, 625 paces wide on the trail, on which there are no pebbles or large boulders except along its brow, where the land is three or four feet higher than that behind, forming a ridge on which a large number of boulders are scattered. This ridge is precisely similar to the present bank of the river in many places, where the lands back from the stream descend several feet to a hay meadow.

Terraces 130, 95, 80, 55 and 25 feet above the river.

From the brow of this terrace a long slope descends to a sandy flat, the whole distance on the road being 500 paces. The brow of this flat, which is thirty-five feet below the last, or ninety-five feet above the river, is strewn with many small rounded and water-worn boulders up to one foot in greatest diameter. Four hundred paces further west along the road brings one to the edge of a similar terrace eighty feet above the river. The land is mostly sand, but a pit three feet deep on the edge of a terrace shows it to be composed of rounded water-worn gravel, with rounded boulders of gneiss up to eighteen inches in greatest diameter. The gravel shows little or no sign of stratification.

Two hundred and thirty paces, for the most part down a gentle slope, brings one to the edge of a terrace fifty-five feet above the river, and again 225 paces lead to the edge of a low terrace close to the river, fifteen feet above the bottom land, and twenty-five feet above the water.

West bank steep.

The west bank of the valley rises steeply from the alluvial bottom land without any sign of terraces, and at no other place in the whole Assiniboine valley are terraces so beautifully shown as they are at Shellmouth.

For the rest of the distance to Millwood, which is situated five miles south of the limit of the present map, the river is very similar in character throughout.

Lightly undulating country.

Ascending the east side of the valley a mile north of the mouth of Skunk Creek, the country is generally level, though in detail lightly undulating. The surface is sandy and through the sand are scattered a few pebbles, but no boulders. Standing on the brow of the hill lovely prospects of the valley extend to the right and left. The sides are steep and more or less irregular, having been fashioned by ancient land-slides that are now overgrown with grass or coppice, form-

ing a declining series of little rounded or elongated knolls, some of which carry a few small oak trees. No terraces are present here, but one can be seen above the mouth of Thunder Creek. Between the hill-sides, lies a beautiful green alluvial floor half a mile wide through which the river winds, its banks thinly fringed with poplar, elm or willow.

Till.

At the top of the bank is a land-slide showing in descending order one foot of sandy loam underlaid by a thin irregular stratum of pebbles and small boulders. Then six feet of a light yellowish-gray unstratified till containing pebbles up to the size of the fist, many of which show clear glacial striæ. Below this is a lenticular mass, fifty feet or more in length, tapering off to both ends, and eight feet thick in the middle, of very irregularly stratified sand and gravel, into which are projecting at the ends bands of unstratified till. The upper part, having a thickness of four feet in the middle, is a soft sand or fine gravel, while the lower four feet is much more compact, and is more closely allied to the till. The whole deposit has possibly been formed by a stream flowing under the ice of the glacier. It is underlaid by at least three feet of light gray till. Lower down the bank Pierre shales were seen.

Included mass of gravel.

A short distance to the south, Smith and Skunk creeks flow into the Assiniboine nearly opposite to each other, the former having deposited a little bar of gravel at its mouth. Skunk Creek has formerly cut out a wide valley, and at and below its mouth the alluvial banks of the river are composed to a considerable extent of stratified gravel, the pebbles of which consist of light gray Odanah (Upper Pierre) shale, which has been washed out of this valley. These gravels are the first indication seen on the river of the presence of Odanah shale on the adjoining higher land. The shale is mixed with many very perfect shells of Unios, pieces of buffalo bones, &c.

Odanah shale.

Millwood shale.

Millwood.

A short distance below Skunk Creek several exposures of Pierre (Millwood) shales were seen in the banks, but it is not until the village of Millwood is reached, five miles south of the limit of the map which accompanies this report, that a good section can be obtained. Here the Manitoba and North-western Railway crosses the valley, and its many deep cuttings show in all more than 200 feet of a very homogeneous dark-greenish gray clay shale with nodules of calcareous ironstone. Some of these nodules show cone in cone structure, and others contain such typical Pierre fossils as *Scaphites nodosus*, var. *quadrangularis*, *Lucina occidentalis*, *Baculites compressus*, *Pteria linguiformis*, *Inoceramus tenuilineatus*, *I. Sagensis*, var. *Nebrascensis* *Nucula* sp., *Dentalium gracile?*, elytron of *Hylobiites cretaceus* and fragments of fishes.

The lower part of the bank is covered, but probably consists of similar shale, and a well dug by the railway on the flat to a depth of 100 feet, is said to have passed to the bottom through similar shale to that in the bank. This would give a thickness of 350 feet of Lower Pierre (Millwood) shales.

The bed of the river at Millwood is 1,309 feet above the sea.

Wells.

West of the valley, along the railway track, the wells dug by the railway company give some interesting sections.

Harrowby.

At Harrowby, just on the top of the west bank, the surface is 1,593 feet above the sea, and a well has been dug on a high alluvial plain or terrace that extends from half a mile to a mile back on both sides of the river. It is 100 feet deep; the upper eight feet passes through stratified sand, and the remaining ninety-two feet through dark gray Millwood shales holding large round and dumb-bell shaped concretions of ironstone. Seven miles further west, near the crossing of the old Ellice and Pelly trail, the surface is 1,640 feet above sea level, and a well was dug 163 feet entirely through gray till, to a bed of gravel from which a plentiful supply of water was obtained. The till holds many pebbles and small boulders of gneiss and limestone, most of which are more or less polished and striated.

Langenburg.

At Langenburg, where the surface is 1,681 feet above the sea level, a well was dug to a depth of 175 feet, the log stating that 165 feet was through clay and ten feet through sand. The material around the mouth of the well was examined, and found to be a bluish clay, apparently mostly derived from the Millwood shales. It is mixed with small pebbles, and a few boulders of gneiss and limestone, the latter of which are beautifully polished and striated.

Churchbridge.

At Churchbridge, where the elevation is 1,740 feet, a well six feet in diameter was dug to a depth of 267 feet. The following is the log as received from G. H. Webster, C.E., engineer of the railway:

Description of material passed through.	Thickness of bed.	Depth of bottom of bed from surface.	Height above sea.
1. Sandy loam	8	8	1,732
2. Clay, with gravel and small stones	12	20	1,720
3. Gray sand	2	22	1,718
4. Rocks and clay, about all rocks	3	25	1,715
5. Blue clay and small stones	7	32	1,708
6. Gray sand	1	33	1,707
7. Soft blue clay with layers of sand 1 inch thick about every 2 feet. No pebbles or boulders	234	267	1,473

In bed No. 5 water was obtained at thirty feet, rising one foot in twelve hours.

In No. 7 small springs of water were struck at eighty and 250 feet. At a depth of 200 feet a well preserved piece of wood six inches in length was found, and has been described by Prof. D. B. Penhallow as a new species of larch under the name *Larix Churchbridgensis*.* The same species was also found in southern Manitoba in post-glacial deposits.

This well has not been visited by the writer, but the beds from 2 to 5 would appear to be quite certainly glacial till, while No. 7 would appear to be a great thickness of inter-glacial (or possibly pre-glacial) clays which have been deposited in a valley or lake basin, before the final advance of the ice which distributed the uppermost till, and striated the surfaces of the boulders imbedded in the lower till.

Bird Tail Creek.

A deposit of similar age is shown in the railway cuttings on the east side of the valley of Bird Tail Creek, where twenty-five feet of stratified sand and gravel is overlaid by twenty-five feet of unstratified till with striated pebbles and boulders.

Russell.

At Russell, a terminus of the Manitoba and North-western Railway, six miles east of the Assiniboine, and 1,830 feet above the sea, the country is all thickly covered with drift. A well half a mile south of the station was dug through 100 feet of light gray till, in which were some polished and striated boulders of gneiss 2 x 4 feet in diameter. 400 yards further east in a light rise, the till was but a few feet in depth, below which the light gray Odanah shales were met with.

Barnardo farm.

At Dr. Barnardo's farm, three miles W.S.W. of Russell, and at about the same elevation, a well has been dug 170 feet through the light gray Odanah shales to the top of the soft dark Millwood shales. This would place the base of the Odanah series here at an elevation of about 1,660 feet above the sea. The surface is irregularly undulating, and here and there are ridges of gravel, often interstratified with till, which have probably been formed beneath the ice of the great glacier of the Assiniboine valley.

*A new species of Larix from the Interglacial of Manitoba. By D. P. Penhallow Am. Geol., Vol. IX. p. 368, June, 1892.

DESCRIPTIVE GEOLOGY.

Formations.

The geological terranes referred to in this and the preceding chapter are shown in descending order in the following scheme:—

- Recent.
- Post-Tertiary
  - Champlain.
  - Glacial.
- Cretaceous
  - Pierre.
    - Odanah.
    - Millwood.
  - Niobrara.
  - Benton.
  - Dakota.
- Devonian
  - Upper Devonian or Manitoban.
  - Middle Devonian or Winnipegosan.
  - Lower Devonian, covered or absent.
- Silurian—
  - Niagara.

Fuller descriptions of these terranes are given in the succeeding chapter on Systematic Geology.

SASKATCHEWAN RIVER.

Mouth of river.

Ascending the Saskatchewan River from the point where it empties into the west side of Lake Winnipeg, the banks for a short distance are low, but they almost immediately rise to a height of fifteen feet and maintain this height up to the foot of the rapids at a distance of two miles and a half from the lake. They are generally sloping and covered with grass, but they appear to be composed entirely of a light yellowish-gray till, while the little beach at the foot of the abruptly sloping bank is strewn with many irregular fragments of white limestone.

Abandoned channel.

Just above the Hudson's Bay Company's post, on the west bank of the river, an old abandoned channel joins the main course of the stream. It varies considerably in width, from a quarter of a mile at its mouth to about 200 yards a mile further to the south, where it again joins the main channel of the river. At this latter point its bed was five feet above the level of the surface of the river in August, 1890. A short

distance from the upper end of the channel a small stream begins to flow down the channel, and after babbling through and among the irregular angular stones with which its floor is covered, falls into the bay at its mouth. In seasons of flood some of the water of the river is said still to flow down this channel. Its banks are from forty to fifty feet high, but are throughout covered with trees or deciduous plants.

On the east side of the old island, which is cut off by this abandoned channel from the high land to the west of it, the river is in some places still cutting down its bank. At one place, a few hundred yards below the head of the old channel, a low exposure of Niagara limestone is seen close to the edge of the river, rising at its highest point to two feet above the water. Its bedding is essentially horizontal, and its surface is smooth and glaciated with strongly marked parallel grooves bearing S. 2° W.

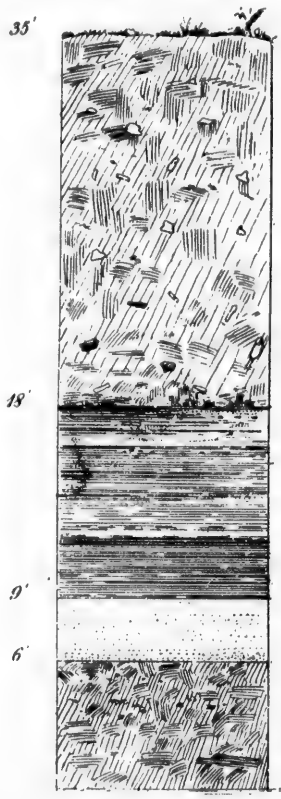
Niagara limestone.

The rock consists of a brecciated magnesian limestone, the pebbles in which are milk-white, very compact, though rather soft, and highly argillaceous, breaking with a vitreous fracture. The matrix, which is much harder but less compact, and often slightly porous, is yellowish-gray, and breaks with a stony fracture. The rock is rather thinly, but irregularly bedded, and along the edge of the water weathers to a light yellow, while the upper part away from the water weathers to bluish-gray. No fossils were found in this band.

Pleistocene beds.

A little further south on the same side of the island a scarped and springy bank thirty-five feet high shows the section of the Pleistocene deposits represented on the following page. The face of the upper portion of the cliff weathers to a milk white. The line between the upper till and the stratified clay is not very sharp, the one appearing to merge almost imperceptibly into the other, while the pebbles become larger and fewer in descending to where the clay is more distinctly stratified. The sand below the clay is very fine at the top, and passes downwards into a fine gravel. The lowest bed of till is partially covered with debris, but both the top and bottom were clearly seen.

Section of Pleistocene at Grand Rapids.



A considerable flow of water rises from the band of sandstone, and the bank below it is generally covered with debris consisting largely of angular fragments of limestone, much of which is derived from close at hand.

The rest of the west bank of this old island, with the exception of the low outcrop of Niagara limestone mentioned above, is covered with debris from these surface deposits, and boulders and pebbles are scattered along the edge of the water. One very large boulder of limestone, fifteen feet in length, is lying in place on the glaciated surface of the limestone, still partly imbedded in the bottom of the

till. It is strongly glaciated, its sides being everywhere scored with striæ.

Following the north bank of the river above the upper end of the old channel to the first prominent point, a thick-bedded buff-coloured dolomite crops out at the edge of the water, holding a large number of *Pentamerus decussatus*, and then crossing to the south side of the river, in a direction 25° south of east the Pentamerus band is again seen with a thickness of two feet. It is exposed at the top of a little cliff, and is underlaid by nine feet of whitish moderately thin-bedded unfossiliferous dolomite. One foot at the bottom is more yellowish and a little thicker bedded than the rest. The brecciated zone is not seen, but is doubtless but little below the beds seen in this cliff. Pentamerus zone.

In the Pentamerus band at the top of the exposure *Pentamerus decussatus* is very abundant, and the following other fossils are found associated with it, viz.: *Favosites Niagarensis*, *Alveolites Niagarensis*, *Lyellia papillata*? *Halysites catenulatus*, *Orthis* sp., *Euomphalus* sp.

Following up the south bank of the river for a quarter of a mile, the Pentamerus band, which has a total thickness of from three to four feet, disappears beneath the level of the water, and the cliff dies away and leaves a willow flat that may be the lower end of an old channel on the south side of the river. In one place, however, east of this flat the Pentamerus band is overlaid by three feet of white moderately thin-bedded limestone. Continuing to ascend the course of the stream, soft yellow or white argillaceous limestones are occasionally exposed on both banks up to within a short distance of the foot of the old portage. It is difficult to give an exact section of these beds, as where they are unprotected by overlying harder rocks they have been more or less completely removed during Pleistocene times, and where so protected the foot of the cliff is buried in a talus of angular fragments from the dolomite above. They would appear to be from forty to fifty feet thick, and the following is the ascending section as seen, the width of the first gap being uncertain. Section below old portage.

Three feet of white moderately thin-bedded limestone (mentioned above).

Ten? feet covered.

Eight feet of a soft light yellow argillaceous limestone, generally porous and containing a large number of impressions of salt crystals. In places the bedding is moderately even and horizontal, but generally it is hardly discernable and the rock breaks into very irregular lumpy pieces. Lying on the shore, and apparently derived from this band, are some nodules of marcasite, and red masses of iron-stone.

Fossils are not plentiful on the south side of the river where this band is best exposed, but a low exposure on the north bank that seems to be a continuation of that on the south bank contains *Strophomena acanthoptera*, *Leptocœlia* and *Leperditia*.

Six feet covered.

Section below old portage.

Fifteen feet of a thin-bedded white horizontal chalky limestone, in places argillaceous, very light and breaking regularly when struck with the hammer. It has a more or less granular structure, occasionally approaching a sandstone in appearance. One bed near the top was strongly ripple marked, and on the edges of slabs broken from this bed the action of the water that covered these ripple marks is seen to have extended down from an eighth to a quarter of an inch, and to be defined by a moderately even horizontal line. A thin band a few feet below the top was found to contain a considerable number of fossils, among which the following have been recognized:—*Favosites Niagarensis*, *Leptocælia* sp., *Rhynchonella*, sp., *Pterinea aviculoidea?*, *Pleurotomaria occidens?*, *Pleurotomaria* sp., *Orthoceras* sp., *Gomphoceras parvulum*, *Leperditia cæca*, and *L. Hisingeri*, vars. *egena* and *fabulina*.

Dolomites.

The white Lower Niagara limestone is sharply overlaid by a hard, tough, light yellowish dolomitic limestone, rather indistinctly bedded. It is generally clearly fragmental, and towards the base contains a large number of impressions of salt crystals. Fossils appear to be moderately plentiful, but they are very difficult to break out and consequently few were collected. Crinoid stems are very abundant, and with them were *Favosites Gothlandica*, *Zaphrentis* sp., and *Strophomena acanthoptera*.

This crinoidal limestone has a total thickness of ten feet and grades up into, and is overlaid by from twenty to thirty feet of a hard brittle yellow dolomite, everywhere evenly bedded and often breaking into thin slabs. The only distinct fossil is a large Stromatoporoid, which occurs most abundantly in the upper strata and often gives the surface the appearance of many closely adjoining low domes. The rock is much jointed and breaks with a smooth porcellanous fracture.

Gorge at Grand Rapids

These dolomitic limestones form the sides of the gorge through which the Saskatchewan flows at the Grand Rapids, standing in abrupt cliffs that often overhang the torrent below. On the south side the foot of the cliff is in places piled with a talus of angular fragments, while on the north side it descends abruptly into the water.

Tramway.

At the upper end of the rapids these compact dolomitic limestone are overlaid by a porous yellow dolomite, generally in moderately thin but uneven beds, and containing many impressions of salt crystals. No fossils were obtained here, but on the tramway similar rock is exposed at a number of places near the top of the grade, and at heights rising to forty feet above the level of the top of the compact dolomite at the head of the rapids. It here contains *Lyellia papillata?* and several other species of corals, with some large Stromatoporoids. It is here best exposed in a cut through two gravel ridges on the brow of a long slope facing towards the east.

About half-way across the tramway a slight surface outcrop exposes two feet of horizontal, gray, white-weathering, thick-bedded, tough but

rather porous dolomitic limestone, and immediately adjoining is a coarse breccia, in which the pebbles are derived from the adjoining rock, while the matrix is dolomite containing a large quantity of coarse well-rounded quartz sand. It would appear probable from its very local occurrence that this is a fault breccia, in which case the origin of the sand is an interesting question, as the only sands of the same character known in the region are the St. Peter's Sandstone below the Trenton, and the Dakota Sandstone at the base of the Cretaceous, though the nearest point at which the latter terrane has been actually observed, lies seventy-five miles to the south-west.

As will be seen by referring to page 182, a somewhat similar breccia occurs at Point Wilkins, on the west side of Dawson Bay, the sand in which has undoubtedly been derived from the base of the Cretaceous. As the sand is much more likely to have run down from above, rather than to have been squeezed up from below, its presence here may denote the former existence of the Dakota Sandstone previous to the wearing back by erosion of the great Manitoba escarpment.

River above Grand Rapids

Ascending the river from the upper end of the tramway, the banks are at first low, or rise in cliffs of glacial and alluvial deposits, but at a distance of two miles and three-quarters, Niagara limestone again makes its appearance on both banks of the stream. On the north side it is a thin-bedded, yellowish-gray, compact, dolomitic limestone very like the beds at the Grand Rapids, and like in them, the surface rises in little low domes, probably from the presence of large Stromatoporoids. On the south bank is a cliff eight feet in height of an orange-gray dolomitic limestone, both thin and thick-bedded. It is very hard and compact, many of the loose slabs ringing sharply when struck with the hammer.

Roche-rouge.

Half a mile further up the river a little cliff six feet in height projects into the stream, and the water rushes past its base with considerable velocity. Its top is a small open meadow covered with grass and strawberry vines. It is composed of horizontal, hard, compact, resonant dolomitic limestone, mostly in beds from half to three-quarters of an inch in thickness. Towards the bottom the rock is rather thick-bedded, not so compact and contains Stromatoporoids, Leperditiæ and other fossils. The weathered surface is generally white, but a new fracture is buff, and where it has been heated by forest fires it is a bright red. The fracture is generally stony, but in some of the larger pieces cut by veins of calcite it is conchoidal.

For the next half mile the shore is composed of similar rock, in places rising into little cliffs, and in other places forming a wide flat, strewn with angular fragments torn off by the ice.

Roche-rouge

One bed was found to contain a great number of cavities out of which salt crystals had been dissolved. The salt has originally composed about a sixth of the mass of this bed.

Another stratum, which is often quite red, contains a great number of specimens of *Isochilina grandis*, var. *latimarginata*, with an occasional example of *Leperditia phaseolus*, along with crinoid stems, *Leptocœlia* sp., and the tail of a *Dalmanites?* In contiguous beds were found *Stromatopora?* sp., *Zaphrentis* sp., *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Lyellia papillata?* and *Strophomena acanthoptera*.

Fossils.

A short distance further up the stream a low cliff, half hidden by the woods along the shore, shows at the bottom compact thin-bedded dolomite similar to the last, overlaid by seven feet of thick-bedded yellow porous dolomite, weathering with a rough pitted face. The rock is brought up by a very light anticline in the centre of which six feet of the thin-bedded dolomites are exposed.

The bank of the river north of Roche Rouge Rapids is an abrupt cliff ten to fifteen feet high, and appears to be composed chiefly of white till with boulders, with a narrow ledge of limestone close to the edge of the water.

Cross Lake Rapid.

At the foot of Cross Lake Rapids a rather conspicuous point projects from the south bank and forms a cliff 150 yards long and ten to fourteen feet high. The limestone composing it is practically horizontal. Four feet at the bottom is a compact hard yellowish-gray dolomitic limestone in thin regular beds, and this is overlaid by ten feet of a thicker and less evenly bedded dolomitic limestone. The upper four feet of this latter bed weathers with a moderately even face. The lower six feet, lying above the slaty dolomite, is very uneven in texture, having compact streaks through it, while much of it is soft and rotten, and generally of a lighter colour than the rest; it weathers with a very rough face and often has the appearance of a conglomerate on account of the presence of many nodules that when broken show the structure of Favosites or Stromatopora.

Fossils.

This nodular band contains a considerable number of fossils, of which the following have been recognized: *Stromatopora?* sp., *Calapœcia* sp., *Zaphrentis Racinensis?*, *Cyathoxonia Wisconsensis?*, *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Halysites catenulatus*, *Lyellia papillata?* crinoid stems, a polyzoon, *Trematospira formosa?*, *Murchisonia* sp., *Pleurotomaria Hoyi?*, *Orthoceras* sp., *Isochilina*, sp.

At the upper end of Cross Lake Rapids, where the river flows out of Cross Lake, a very similar cliff forms a prominent feature on the

south shore. It consists of horizontal buff-coloured, dolomitic limestone, the top beds of which are thick, compact, and very hard, while four feet at the bottom are very soft, like the upper beds at the foot of the rapids. The harder beds contain a few imperfectly preserved fossils, and also some large and regularly preserved casts of single crystals of salt.

Cross Lake.

On the south shore of Cross Lake there are many little cliffs of apparently similar limestone. One of these, near the west side, was found to consist of four feet of thick-bedded yellowish, rotten, dolomitic limestone similar to that at the last rapids, and containing a few fossils such as *Stromatopora?* sp., *Favosites Niagarensis*, crinoid stems, *Strophomena acanthoptera*, &c. It is underlaid by compact thinner-bedded dolomitic limestone apparently holding no fossils.

Demi-charge Rapid.

At Demi-charge Rapid similar hard dolomite forms low cliffs on both banks, and just above the rapid a cliff on the south shore rises to a height of from fifteen to twenty feet, composed throughout of light yellowish-gray horizontal dolomitic limestone, both thick and thin-bedded, and generally hard and compact. The only fossil seen was the common *Strophomena*. A little higher up the river a cliff eight feet high faces the stream, above which is a terrace, apparently an old shore line, extending back to the foot of a cliff twelve feet high, and now overgrown with trees. The foot of the lower cliff is strewn with sharp angular fragments broken from its face. The bottom bed is filled with shot-like concretions, which weather into little pits.

On the west side of a small lake-like expansion about a mile and a half further up the stream, a very similar hill is seen with a cliff ten feet high facing the water, and another cliff rising ten feet higher behind a terrace in the poplar woods. The rock at the bottom is a thin-bedded dolomitic limestone, above which is a thick-bedded, rotten, dolomitic limestone, and this again is overlaid by a harder compact evenly bedded dolomitic limestone. Some of the middle beds contain a few fossils such as *Strophomena acanthoptera*, *Rhynchonella*, *Leptocælia*, &c.

The Narrows.

Also at the north-east point of land below "the Narrows" low cliffs of similar thin-bedded dolomitic limestone occupy the shore for several hundred feet.

Cedar Lake.

South-westward from "the Narrows," which is accounted as the eastern extremity of Cedar Lake, a gradually widening arm extends for twelve miles to the main body of the lake. It is dotted with many beautiful rocky islands, and while the north shore is generally low and wooded, the south shore rises in many places in prominent cliffs from fifteen to twenty-five feet in height.

Rocky islands. The rock on both the islands and the shore is very much the same throughout, consisting of light yellow, very hard and compact dolomitic limestone varying greatly in the thickness of the beds. The base of the cliff is generally covered with a pile of large angular blocks fallen from the thicker beds towards the top. The summits of the cliffs are generally level, but do not show glacial striæ, as they have evidently been eroded by meteoric agencies, while some of the rocky islands that rise but a very few feet above the water, and from whose surface the till has probably been very lately removed, show beautiful glacial striæ bearing S. 18° W. Very few fossil [illegible]re found in these rocks, the only one that was recognized being [illegible]mmon *Strophomena acanthoptera*.

Fort Island. From Rabbit Point westward, the south shore alone was examined, and no Palæozoic rocks were seen between that point and Fort Island. At the north point of this island a little vertical cliff six feet high, composed of horizontal light orange-yellow porous dolomite in heavy even beds, rises from the edge of the water. It contains a considerale number of fossils, of which the following were collected: *Cyathaxonia Wisconsinensis?* *Zaphrentis Racinensis?* *Omphyma?* sp., *Alveolites Niagarensis*, *Halysites catenulatus*, *Strophomena acanthoptera*, *Leptocœlia?* sp., *Meristella?* sp., *Trematospira?* sp., *Orthoceras* sp., and *Leperditia Whiteavesii*.

West shore of Cedar Lake. From Fort Island westward many of the islands around the mouth of the Saskatchewan, as well as points on the shore, both to the north and south, are composed of similar dolomite. On a prominent point projecting from the south shore, the rock is a light coloured dolomite, yellow in places where it is much acted on by the water. In some places it is thin-bedded and almost slate-like, but generally the structure is concretionary on a large scale, so that the surface has a mammillated appearance, the domes being from six to twelve feet in diameter, and in them the thin-bedding is lost and the rock becomes somewhat porous. They inclose such fossils as *Favosites Niagarensis?*, *Halysites catenulatus*, *Strophomena acanthoptera*, *Rhynchonella altiplicata?*, *Atrypa reticularis*, *Polytropis*, sp.

The shore is here piled with great angular blocks from three to four feet in thickness that have evidently been broken from a bed just below the level of the water and piled up into their present position by the ice.

Chemahawin. Chemahawin, where the Hudson's Bay Co. have a trading post, was the most westerly point on the Saskatchewan River reached by the expedition. In its immediate vicinity from eight to ten feet of horizontally bedded dolomite outcrops on the bank. It is generally

light gray, and sometimes compact, but it is often yellow and porous, and is throughout very thick-bedded. A careful search revealed the presence of such fossils as *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Halysites catenulatus*, *Strophomena acanthoptera*, *Leptocœlia*, sp., *Orthoceras* sp., *Illænus* sp., and *Leperditia Whiteavesii*.

Leaving Cedar Lake at its south-western angle, a winter trail, known as the Western Mossy Portage, leads through a thinly wooded tamarack swamp on a gently rising plain to the shore of Lake Winnipegosis.

Lake Winnipegosis.

Following the shore eastward, no Palæozoic rocks are seen up to the north-east angle of the lake, but on the north-west point of Ami Island flat-lying and thin-bedded yellowish magnesian limestone of Niagara age is seen for the first time. Following the shore of the island this limestone, which is at first slightly porous, becomes hard, thin-bedded and flint-like, and the bedding becomes wavy. In places it contains large nodules of gray chert. Probably from ten to fifteen feet of rock in all is exposed on this island. It contains a considerable number of species of fossils among which *Strophomena acanthoptera* is the most abundant, while *Pterinea* sp., *Grammysia ?* sp., *Murchisonia* sp., and *Pleurotomaria ?* sp., also occur. North-east shore.

East of Ami Island the beach is flat and sandy, but generally scattered over with fragments of dolomite. Some of these are Silurian and doubtless of more or less local origin, while others are Devonian and contain such typical fossils as *Stringocephalus Burtini*. Long Point peninsula.

These are evidently transported masses, and as the direction of glacial transportation is from N. 20° E., as shown by glacial grooves and striæ in the immediate vicinity, they would prove the existence of the Stringocephalus dolomite in the unknown area between this point and the south end of Cross Lake during the latest glacial times, and it is not improbable that an outlier of this dolomite still exists, and forms a capping to the high land seen in that direction. On Ami Island boulders of the Pentamerus band in the Niagara series are also found, having been brought from the same direction, and with them are small rounded masses of white sandstone holding nodules of Marcasite. These are similar to the nodules found on Pemican Island described on page 169, and like them are not improbably derived from an outlier of Dakota sandstone in the immediate vicinity. In view of the fact that Marcasite readily undergoes decomposition into soluble sulphate of iron, which would soon be washed away by the waves Boulders. Nodules of Marcasite.

it would appear that these nodules have only recently been shoved up on the beach, and could not have been transported from the north so long ago as the glacial age. We must, therefore, infer that a small outlier of Dakota sandstone exists beneath the level of the water on the south side of this island, and that it has been protected from destruction, at the time when the Laurentide glacier passed southward over the country, by the shelter of the island to the north of it, and that it is even now touched and scraped by the lake ice only in seasons of extreme low water, such as was the summer of 1889.

Low sloping rock.

Returning to the shore at a point opposite two small islands, originally bedded rock outcrops at the edge of the water, consisting of a fine-grained yellow, moderately compact magnesian limestone, fairly thickly and evenly bedded, and breaking under the hammer in any desired direction.

Following the shore southward the beach is strewn with angular fragments of magnesian limestone, similar to that already seen, broken by the ice and frost from the beds below. Some chalybeate springs flow out on the beach, and in the vicinity is a light yellowish or pinkish dolomite holding typical Niagara fossils, as well as chert concretions.

At lat. 52° 54′ 15″ in a little bay just north of a point of land, the beach consists of a light gray thin-bedded compact dolomite in which the impressions of ostracods are very numerous. The beds have a slight dip S. 80° W. and are very much cut by parallel jointage planes running from south-west to west. The following fossils were found in this dolomite: *Streptelasma* sp., *Strophomena acanthoptera*, *Rhynchonella* sp., *Ilionia?* sp., two species of *Murchisonia*, *Pleurotomaria* sp., *Orthoceras* sp., *Isochilina grandis*, var. *latimarginata*, *Leperditia Hisingeri*, and its vars. *fabulina* and *gibbera*, *L. marginata*, and *Acidaspis perarmata*.

Fossils.

Massive dolomite.

At the point itself a massive porous dolomite from eight to ten inches in thickness makes its appearance, being apparently about three feet above the strata just mentioned. It is apparently made up largely of remains of Stromatoporoids and contains many large concretionary nodules of chert. Continuing further south this layer is overlaid by a few feet of similar but thinner bedded dolomite, the bedding planes of which are generally rough and irregular. The most common fossil here is *Strophomena acanthoptera*.

Thin-bedded dolomite.

In lat. 52° 52′ 30″ the shore is composed of thinly stratified dolomite holding *Strophomena acanthoptera*. The beds are generally undulating and some are slightly porous, while others are very compact and porcellanous. They all appear to dip lightly out into the lake in a direction S. 85° W., and the bottom for a long distance is a gently inclining surface of smooth rock.

Similar rock forms or underlies the beach all the way to the point of the peninsula, generally thin and evenly bedded and broken into sharp angular fragments by jointage planes, which are often arranged in concentric circles.

For a mile and a quarter up from the point, on the east side of the peninsula, the shore is low and the water off it is very shallow, and then for three-quarters of a mile the Niagara rocks again make their appearance. At first is a low exposure on the beach showing two feet of light yellow porous dolomite in rather thick beds, in which neither fossils nor chert nodules were seen. 100 yards to the south of this exposure is a spring surrounded by a red slime. The water tastes distinctly of common salt and sulphuretted hydrogen.

Nodules of chert.

At a point north of this portion of the shore the rock is thick-bedded, holding a large number of nodules of chert, being apparently a continuation of the cherty dolomite seen in lat. 52° 54′ 15″ on the opposite side of the peninsula. This would indicate a strike of N. 20° W. for these rocks, which agrees fairly well with that which would be deduced from the dips given above.

The shores of the deep bay to the east of this peninsula are generally low and without rock exposures, while across its north end extends the high ridge that has continued quite unbroken from the northern point of the lake west of Western Mossy Portage.

Light anticline.

At a prominent point on the east side of the bay, in lat. 52° 53′ 10″, Silurian dolomite again makes its appearance on the shore. It is yellowish-gray, more or less compact and thick-bedded, and rises in a light anticline striking S. 50° W., though the general dip of the beds also appears to be in that direction at a low angle. Here and there throughout the rock are small cavities, the sides of which are lined with loose semi-crystalline dolomite. Small nodules of chert are not uncommon, but other fossils than *Strophomena acanthoptera* are very rare.

Two miles to the southward a rather thin and not very evenly bedded dolomite underlies the beach. It is in places of a light colour, more or less coarse-grained, and contains nodules of chert, with *Strophomena acanthoptera* and other fossils, while in other places it is very compact and much fractured, and contains *Isochilina grandis*, var. *latimarginata* and other ostracods, with a species of *Proetus*.

The beds are evidently the same as those outcropping in lat. 52° 54′ 15″ on the west side of Long Point peninsula, and a line connecting the two points would indicate a strike of N. 40° W. This varies considerably from the strike previously obtained and serves as a instance of the fact that neither strikes nor dips are at all constant in detail in these flat-lying beds.

Beach of angular pebbles.

A mile further to the south, and near lat. 52° 50′, the shore is composed of thin-bedded hard dolomite cut by many jointage planes, and the beach is scattered with angular fragments of the same rock, but near the south end of this exposure the dolomite becomes very porous and uneven and contains a considerable number of fossils, most of which were too fragile to permit of being broken out, but concretions of chert are almost entirely absent. Among the fossils *Strophomena acanthoptera* was the most common, while species of *Murchisonia*, *Orthoceras*, &c., were also collected.

A short distance further to the south thin-bedded dolomite is again seen, and the rest of the shore as far as the point consists of angular fragments of dolomite scattered through a matrix of soft clayey sand flattened and grooved by the shoving of the ice in spring.

South of the point the shore turns eastward for two miles and a half at right angles to the direction of glaciation, and then turns again and continues parallel to its former direction.

Vesicular dolomite.

In lat. 52° 46′ light gray porous or almost vesicular dolomitic limestone makes its appearance in beds of from half an inch to an inch in thickness. It continues for a mile along the shore and becomes quite fossiliferous, containing large numbers of *Strophomena acanthoptera*, associated with *Rhynchonella* sp., *Murchisonia* sp., *Isochilina grandis*, var. *latimarginata*, and *Leperditia* sp. The beds dip uniformly N. 65° W. into the lake at an angle of two or three degrees.

At a point a mile to the north these beds are hardened and very much cracked by a light anticline striking about east and west, and are overlaid by a foot or two of thin-bedded compact slate-like dolomite also holding *Strophomena acanthoptera*, which breaks into small rectangular blocks, covering the beach with a rough debris.

The porous dolomite continues to compose the shore to lat. 52° 44′ when there is again a sharp bend to the east.

Goose Islands.

Returning northward to Goose Islands, the north end is found to be composed of porous dolomite similar to that on the shore opposite, with a very light dip in a westerly direction, and the north end of the middle island is also composed of the same dolomite, with *Strophomena acanthoptera*, while the rest of the islands consist of sand, clay and boulders, these latter being more numerous than on any part of the shore to the north.

Further south, in lat. 52° 42′, the shore is composed of similar flat-lying, moderately thin-bedded dolomite, and a mile further south similar rock is again exposed on the shore, and on a horse-shoe-shaped island a mile off the shore. No fossils of any kind were found.

The shore between and around these isolated exposures was scattered with angular fragments of similar rock, and in some of these fragments were ostracods similar to those collected further north.

Pickerel Creek

A short distance north of the mouth of a creek that flows from Pickerel Lake, and empties into Winnipegosis Lake in lat. 52° 36′ 46″, the beach is composed of a light gray thin-bedded dolomite, with a dip of 2° a little south of west. The surface is undulating, rising into little rounded mamillæ. The beds vary from the thickness of paper up to half an inch, becoming virtually a slaty dolomitic shale. The colour is light gray or bluish-gray, often streaked with red or pink. It is very compact and brittle and cut by many fissures, owing to which it readily breaks into small fragments, with which the beach is thickly strewn.

Oolitic dolomite.

Just south of the mouth of the brook a bed of dolomite half an inch in thickness makes its appearance, in which are many white calcareous dots, which rapidly weather out and give the weathered surface of the rock a very pitted appearance. This bed is very similar to that at Demi-charge Rapid mentioned on page 151.

Similar rock can be seen at salient points along the shore down to lat. 52° 33′ 40″. Fossils were carefully searched for throughout, but only very obscure traces were discovered.

Thence southward to lat. 52° 30′ 30″, the shore is low and flat, scattered with angular fragments of pink and white thin-bedded dolomite, and boulders of gneiss become much more numerous.

Vesicular dolomite.

Here the shore bends to the west of south, parallel to the line of glacial transportation, but just at the bend is a low exposure of light gray and very vesicular dolomite in a bed two inches thick, dipping a little north of west at an angle of 5°. The dolomite is generally tough and compact between the vesicles, and the bed is generally darkened, possibly from the presence of a certain amount of carbonaceous material. The vesicles would appear to have been caused by the solution of crystals of common salt that have been included in the rock. No fossils could be found, and the rock is not unlike that of the Stringocephalus zone of the Devonian shortly to be described from other parts of the lake, but in the absence of clear evidence it will be safer to consider it as a band in the upper portion of the Silurian or near the base of the Guelph.

For the next five miles and a half towards the south, the shore is without rock exposures, and is scattered with more or less angular fragments of thin and irregularly bedded dolomite, all of which appear to be of Silurian age, no Devonian fossils being found. This tends to

support the conclusion that no Devonian strata have yet made their appearance near the lake shore to the north, as that is the direction from which boulders have been transported.

Devonian rocks.

At a rounded point opposite a long island, in lat. 52° 26′ 30″, the beach is composed of angular debris, much of which is a light brownish-gray impure dolomite that has probably been broken from bedded rock in the immediate vicinity. It is finely crystalline and generally rather compact, though in places broken by little vesicles made by the solution of salt crystals. It does not effervesce in cold weak hydrochloric acid, but in boiling acid it dissolves readily, leaving a quantity of dark brown residue. A few obscure fossils, such as brachiopods and gasteropods, were found in it, but they were not sufficiently well preserved to determine its taxonomic position. The rock itself is somewhat similar to a bed underlying the Stringocephalus zone found at the base of a cliff in Dawson Bay, and which is clearly of Devonian age. Therefore as the rock is of rather peculiar character, in default of other evidence, it is here placed in the Devonian, and its parent bed is doubtless in the immediate vicinity.

Very shallow water.

To the southward the beach continues exceedingly low, and the water is so shallow that it cannot be navigated near the shore, even with a canoe, without considerable difficulty. There is no sign of the Palæozoic rocks down to lat. 52° 23′, where a hill rises back from the shore to a height of thirty-five feet above the water, its lightly rounded crest being composed of more or less water-worn pebbles, chiefly of white limestone, though a few are of gneiss. On its side, sloping towards the lake, is a ridge fourteen feet above the water level, and this ridge, with the present beach, is composed almost entirely of large or small pebbles of a light brownish vesicular semi-crystalline dolomite, weathering into very typical irregular roundish nodose masses like the rock at Devil's Point. No rock was seen in place.

Island Z.

For six miles and a half further to the south the shore is very low, and scattered with loose fragments of nodose dolomite, and thin slabs of harder, more compact, probably Niagara dolomite. The north shore of Island Z, lying in north latitude 52° 18′ 30″, appears clearly to be composed of Monroe Point beds, for while no rock is seen in place, the shore is strewn with angular masses of cream-coloured tough vesicular dolomitic limestone holding a number of fossils such as crinoid stems, *Astræospongia Hamiltonensis*, *Spirorbis omphalodes*, *Pinacotrypa marginata*, *Fenestella vera*, *F. dispanda*, *Productella subaculeata*, *Conocardium Ohioense*, *Leperditia ? exigua*, and *Proetus mundulus*.

South of this island the shore is thickly strewn with boulders of gneiss and dolomite, being often backed by an ice-shoved boulder

wall, and no rock is seen in place for ten miles until latitude 52° 10′ 20″ is reached, where a hill rises by an easy slope from the edge of the water to a height of sixty feet, its sides being strewn with dead birch, spruce and poplar. Its crest is slightly rolling parallel to the shore, and is covered with pebbles and rounded cobbles, and its western face with large masses, possibly some of them being in place, of a thick-bedded light yellowish-gray porous and vesicular dolomite, in which were but few and ill-defined fragments of fossils. The rock is, however, almost precisely similar to that on the Island off Whiteaves Point in Dawson Bay, belonging to the lower part of the Stringocephalus zone. Rocky hill.

Close to the edge of the water, a low cliff of a light yellow soft porous dolomitic limestone, chiefly characterised by the presence of a large number of fragments of stems, plates and pinnules of crinoids, extends for 100 yards along the beach. It is in beds of from one to three inches in thickness, and is generally horizontal, but in some places it is tilted to the south, at angles as high as eight degrees, to a light fault, beyond which the beds are again horizontal.

Five miles further south, Point Brabant overlooks the lake from behind a row of large wide-spreading elms, its base being generally ten feet above the water, and its crest at its highest part twenty-six feet higher. At the first good exposure, the lower sixteen feet of the cliff consists of a hard, compact, light yellowish-gray dolomite, resounding when struck and breaking with an irregular fracture. Near the middle of this band, at nine feet from the bottom, is a thin bed of clay shale. The dolomite is not very fossiliferous, but the following species were collected from it. *Cyathophyllum vermiculare*, var. *præcursor*, *Alveolites* like *cryptodens*, *Productella subaculeata*, *Spirifera Richardsonii*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *A. reticularis*, var. *aspera*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Omphalocirrus Manitobensis*, *Loxonema altirolvis*, *Hyolithes alatus* and *Orthoceras Hindii*. Point Brabant. Fossils.

The upper ten feet of the cliff is a somewhat similar dolomite, but contains very few traces of fossils.

The beds appear to be in general horizontal, but twenty-five paces further south they are broken by a light fault with a downthrow of two feet to the north.

For the next 300 paces the beds decline slightly to the south, parallel with the decline in the top of the cliff. On the beach were scattered a few fragments of a limestone conglomerate, probably from beds near the bottom of the cliff. Section along the shore.

Point Brabant.

In the next 110 paces the beds of dolomite dip fifteen feet to the south. In this latter stretch the beds are very hard and compact, but much broken by little joints, so that they have been worn into caverns by the waves. Some thin beds of clay run through these lower beds.

In the next fifteen paces the cliff is fifteen feet high, and the rock is considerably broken, but it appears to be rather shaly towards the top.

In the next twenty-five paces the rock dips six feet, and here shows a cliff twenty feet high, the beds being white magnesian limestone, occasionally stained with dull pink, and holding numerous *Atrypas*, &c.

At this point there is a fault with a downthrow to the south. On the opposite side of the fault twenty feet of light red and gray shale is exposed, dipping S. 25° E. at an angle of 45°.

Throughout this distance it would appear that about thirty feet in all of dolomitic limestone, and twenty feet of red and gray shale is exposed, the latter being higher than the former, and having been dropped into its present position by the last-named fault.

For about 200 paces the shore is rather low to an exposure of a yellow semi-crystalline dolomite through which are running many round tubular cavities that possibly represent natural moulds of *Pachypora polymorpha* or a similar coral that has entirely or almost entirely decayed away. The exact position of this bed remains undetermined.

For the next 240 paces the bank is composed entirely of till and boulders, and is about three feet in height. At this point it rises to a height of ten feet, consisting at the bottom of six feet of yellow argillaceous limestone, overlaid by four feet of white limestone.

For 100 paces similar rock is practically horizontal, at the end of the distance the cliff consisting of four feet of brittle argillaceous limestone, overlaid by six feet of thick-bedded white limestone.

Continuing down the shore for forty paces a sharp anticline suddenly brings up four feet of a light yellowish-red calcareous argillite.

Ten paces further the cliff is twelve feet high and is composed of eight feet of yellow and pink, hard, compact often thin and irregularly bedded argillaceous limestone, holding specimens of *Atrypa*, &c., overlaid by four feet of white thick-bedded limestone.

For the next thirty-five paces the beds are difficult to follow as they are a good deal crumpled, but they appear to have a light dip of about three feet to the north. Here there is an almost vertical fault striking S. 65° E. with a downthrow to the south, probably of not more than five feet. On the south side of it is a cliff of limestone eleven

feet in height, with the friable limestone at the bottom, while on the north side are six feet of light gray argillaceous limestone, becoming almost a clay shale at the top, where it is also of a pinkish colour.

Sixty paces further the cliff consists of six feet of hard limestone, overlaid by three feet of a light pink hard calcareous shale.

Thirty-five paces further, the section is terminated in two feet of a white thick-bedded limestone holding *Atrypa reticularis*, *Atrypa aspera*, *Paracyclas elliptica*, &c. The beds are practically horizontal, though possibly with a very light dip towards the north.

South of Point Brabant, Mr. Dowling reports that the shore is scattered with boulders, and marsh often stretches for a considerable distance inland, no rock in place being seen till Net Point is reached in north latitude 51° 54′ where there is a low outcrop of three feet of cream-coloured tough dolomite dipping north at an angle of 10°. It evidently belongs to the Stringocephalus zone, and contains a few fossils such as *Murchisonia brevispira*, *Euomphalus turbinata* and *Macrochilina* sp. Net Point.

In latitude 51° 47′ 20″ a low exposure was also observed by Mr. Dowling below the surface of the water, but its character could not be determined.

Descending to the south end of the lake, and beginning on the west side of the point west of Meadow Portage, a low anticline brings a hard limestone three feet above the water, the outcrop extending seventy paces along the shore. The strike of the anticline is N. 30 W., and the dip about 3° away from the middle on each side. The rock consists of a yellow hard fine-grained semi-crystalline highly dolomitic limestone, in which are many vesicular cavities apparently caused by the former presence of crystals of common salt. South end of lake.

No fossils were seen except a wide-spreading Stromatoporoid, but from the position and character of the rock it is evident that it belongs to the Winnipegosan formation of the Devonian.

Five-eighths of a mile further west along the shore, a thin-bedded compact limestone is exposed for 150 feet. It has a dip of 5° S. 55 W., exposing in all twelve feet. Averaging the dip between this and the last exposure as 4°, the total thickness of beds covered between the two points would be 230 feet. The dip may, however, not be persistent, and small faults are not unlikely to have occurred in the covered interval.

The rock is a somewhat magnesian limestone of a light gray or pinkish colour, and some of the beds contain large numbers of *Atrypa reticularis*, while *Paracyclas elliptica*, *Omphalocirrus Manitobensis*, *Euomphalus subtrigonalis*, and *Loxonema altivolvis* were also

found. It represents the lower beds of the Manitoban formation of the Devonian.

Charlie Island. Four miles further west, on Charlie Island, several exposures of similar Manitoban limestone may be seen in cliffs rising at the north end to a height of ten feet, generally brought up by anticlines with an average strike of N. 45° W. The cliff at the north end of the island shows three feet of a compact, thick-bedded to regularly bedded limestone, underlaid by nine feet of a compact but irregularly bedded limestone, which breaks readily into small fragments under the action of the water. The stratification is undulating and the main anticline runs S. 45° W., from which the beds dip outwards at first at an angle of 25°, which, however, rapidly decreases.

At the north end of a small island a few yards to the west, a cliff four feet in height shows the lowest of the above beds in an anticline striking N. 55° W., with the beds dipping at first 12° from the middle line. 300 yards further south, on the west side of CharlieIsland, three feet of similar beds are exposed.

On the east side of the island several exposures of similar limestone form cliffs just behind the beach, one of which shows twelve feet of strata. They are brought up by an anticline striking N. 30° W., from the east of which the beds dip away at first at an angle of 12°.

On a small island north of Charlie Island, similar white limestone rises in little cliffs, four feet above the water.

In all these exposures fossils are moderately plentiful and among the most common are *Cyathophyllum vermiculare*, var. *praecursor*, *C. petraoides*, *Alveolites* like *cryptodens*, crinoidal columns, *Productella subaculeata*, *Strophodonta arcuata*, *Atrypa reticularis*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Evomphalus subtrigonalis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Orthoceras Hindii*, *Ptyctodus calceolus*.

Snake Island, north end. Leaving Charlie Island and crossing two miles of open water in a north-westerly direction we reach Snake Island, which is a long, narrow and almost bifid island lying north and south. Beginning at its northern end and proceeding first west and then south, a cliff 10 feet high of white, thin-bedded, well stratified limestone is found to extend along the shore for 200 yards. At the east end of the cliff the beds rise from the edge of the water with a dip of 4° S. 85° E. Towards the middle the beds are more irregular and break away in small fragments, while at the west, they are even and about horizontal, and then with a light dip descend to the edge of the water.

230 paces S. 35° W. the same beds again appear on the shore and continue to rise for eighty-five paces, where the cliff is 17 feet 6 inches

in height. This point appears to be the centre of a domed anticline, as the rock dips from it in both directions along the shore, and at the same time back towards the centre of the island. Eighty-five paces further south-west along the shore the cliff is only six feet high, its base being three feet above the water, and the beds appear from the lake to be nearly horizontal, while they dip back at a low angle. Domed anticline.

Seventy paces further a continued low dip has caused the beds to disappear below the gravel beach, four feet above the water.

In the highest part of the cliff, the bottom being about three feet above the water, the rock is a white limestone very much the same as that seen at Charlie Island. For six feet at the bottom, the beds are more brittle than those higher up the cliff, but they are not worn into little caves such as are seen at the foot of some of the cliffs on the former island. All the beds are cut by almost vertical jointage planes running from top to bottom.

The taxonomic position of the beds here seen would appear to be near the base of the Manitoban formation and a little above those outcropping on Charlie Island. A few species of fossils, such as *Atrypa reticularis*, *Atrypa aspera* and *Paracyclas elliptica* are moderately plentiful, but with these were also found *Cyathophyllum vermiculare*, var. *præcursor*, *Alveolites vallorum*, *Orthis striatula*, *Cyrtina Hamiltonensis*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Euomphalus subtrigonalis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, *Cyrtoceras occidentale*, *Gyroceras submamillatum*, *Dinichthys Canadensis*. Fossils.

On the west shore of the southern expansion of the island is a low exposure of similar white thin-bedded limestone dipping regularly S. 45° W., at an angle in places as high as 30°. About twelve feet in all is seen. It contains many of the fossils mentioned above, along with *Cyathophyllum profundum* (var.), *Alveolites* like *cryptodens*, *Stromatopora Hupschii*, *Productella subaculeata*. South end.

Snake Island is classic ground in the history of western geology. It was here that Prof. H. Y. Hind, in 1858, made the collection of fossils that first determined the existence of Devonian in Manitoba. The species then collected are all included in the above list with the exception of *Orthis striatula* which has not been found by the writer.* First record of Devonian in Manitoba.

In the early part of the same year Mr. A. W. Wells, acting as assistant to S. J. Dawson, visited the island and states that the rock

* See Rep. on Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind, 4to. Toronto, 1859, p. 93, and App. by Mr. E. Billings, pp. 186-7.

is "a whitish limestone, full of organic remains,* but their character was not determined.

Point south of Snake Island.

Leaving Snake Island and crossing two miles of open water, a point is reached where similar white Manitoban limestone containing the same fossils, forms the beach for a short distance, dipping at an angle of 4 down to, and beneath the surface of the water.

At another point three-quarters of a mile further south similar limestone dips S. 85° E. at an angle of 5°, and three-quarters of a mile still further south at the bottom of a bay it is dipping S. 65° E. at an angle of 4°, and on a long point forming the south boundary of the bay it is dipping S. 35° E. at an angle of 7°.

The shore in this vicinity is low, and often guarded by an embankment of boulders, behind which is a broad expanse of marsh.

Two miles west of Snake Island a long point projects towards the north, and on its west side is a slight exposure of similar limestone holding some of the same fossils, and dipping S. 85° W. at an angle of 5°.

Mossy River.

The only remaining exposures discovered near the south end of Lake Winnipegosis are on Mossy River, one at the crossing of the old Canadian Pacific Railway location, a mile up from the mouth of the river, and the other a little higher up.

Pink-tinted limestone.

The former outcrop shows, for a distance of thirty-five paces on the west bank of the river, a white or pink-tinted limestone. It is thin-bedded and rings when struck with the hammer, being very similar in character to the rock seen on Manitoba Island. In the middle of the exposure it is much broken, and the fractures are often filled with crystals of calcite, but at both ends it has a fairly regular dip of 30 to 40° in a direction S. 5° W. About four or five feet in all of the rock is exposed. The beds are not very fossiliferous, the only distinguishable form being *Cyrtina Hamiltonensis*. Similar rock extends for twenty paces along the east bank of the stream, a few yards higher up. It is here dipping S. 20° E. at an angle of 8°.

From a quarter to half a mile further up the river, on the west bank, is a cliff about sixty yards long and from eight to nine feet high, consisting of white limestone similar to the last, thin-bedded, the bedding being often distinctly shown by fine lines of coloration. The face of the cliff, which runs S. 15° E., is parallel to the strike of the beds, which appear to have a dip of 12° N. 75° E., though they are very undulating. The lower beds break somewhat irregularly, and weather to a light brown. No determinable fossils were found, but the rock is

* App. (No. 36) to the 17th vol. of the Journals of the Legislative Assembly of the Province of Canada. Report of S. J. Dawson, Esq., C.E., p. 7.

doubtless of the same age as that a little further down the river, and appears to represent some of the higher beds of the Manitoban formation, such as are seen at Point Wilkins, and on some of the islands in Swan Lake.

The rest of the banks of Mossy River and the shores of Lake Dauphin are composed entirely of glacial and alluvial deposits.

From the mouth of Mossy River the western margin of Lake Winnipegosis is low, and shielded by a wall of boulders of gneiss and dolomite, behind which is a grassy meadow stretching back to a poplar forest.

Monkman's Salt Springs.

At Monkman's Salt Springs, the shore is straight, and composed of small boulders and pebbles of gneiss and limestone, rising, 100 feet back from the water's edge, in a low ridge of rounded gravel, wooded with a few small willows. Behind this a grassy prairie runs N. 65 W. 460 paces, rising in the distance about eight feet. To the north is a grove of poplar and small oak, while to the south the poplar soon becomes mixed with a little spruce.

At the end of the above distance a slight grassy knoll fifty feet in diameter rises eighteen inches above the general surrounding level. In the centre of this knoll are several irregular holes surrounded by a red incrustration and filled with a clear brine, which rises from several small springs in the bottom of the holes. The springs flow in all about fourteen to twenty gallons of brine an hour, which flows out over the surrounding land and evaporates or sinks into the ground. (The temperature of the water on July 1st was 42° F., and the salinometer showed a salinity of 10 per cent.) Bubbles of colourless, odourless and uninflammable gas rise every few minutes in this spring, especially when the surrounding sod is pressed down by walking over it. The water has been analyzed by Mr. Hoffmann of the Geological Survey and found to contain 1347·08 grains of common salt to the imperial gallon.

West of the above spring is a flat, somewhat in the form of a circle, a quarter of a mile in diameter, almost totally devoid of vegetation. It is bounded on the north by open woods of poplar and oak, and on the south by a forest of spruce. On the west, in which direction the land declines very slightly, beyond two small groves of poplar is a low-lying meadow stretching to the north and south. In this meadow, half a mile from the first spring in a south-westerly direction is a small marshy lake, which stretches three-quarters of a mile to the south, and in which the water is slightly brackish. On the above arid flat are the ruins of several old houses, and lying about are a number of broken and rusted iron pans in which salt was

Ruins of houses.

Monkman's Salt Springs. (Contd.)

formerly made for the use of the [illegible] River settlement. Several wells have also been dug here in the clay or till, and the cribbing around them is still almost unbroken. They are now full of salt water, and in one of them, which is ten feet deep, and lying S. 65° W. from the spring above-mentioned, the water was standing at 72° F. and had a salinity of 18 per cent. This water was found by Mr. Hoffmann to contain 3099·41 grains of common salt to the imperial gallon. In another well close by, the water is 70° F., and has a per cent salinity of 6. Many shallow pits in the vicinity contain water ranging in salinity from 16 to 24 per cent, the latter being the highest, but perhaps the most common. In places where the ground has been overflowed, there is a light crust of salt on the surface.

No rock is seen in place in the vicinity of these springs, and they appear to rise through the general covering of till.

Cliff of limestone.

For some distance northward the shore is low and without rock exposures, the prominent points being composed of transported boulders, but in the bottom of a little protected bay in latitude 51° 54′ a beach of limestone pebbles, thirty feet wide, slopes up for four feet to the base of a little cliff of limestone three feet in height. The water off the shore is deep, with a soft muddy bottom.

The rock is a fine and even-grained light yellow argillaceous lime[illegible], obscurely stratified, the layers being in the main horizontal, but locally undulating, without jointage planes, but breaking into very irregular fragments. The upper bed is hard and compact, but traversed by many thin veins of calcite, and weathers to a pure white. Below this hard bed is two feet of a yellowish soft clayey limestone, running [illegible] regular semi-nodular limestone.

No fossils were found, but the rock doubtless forms a portion of the argillaceous band near the base of the Manitoban formation, and underlying the limestone of Snake Island and other localities.

Coarse [illegible]

The northeastern side of the bay is bounded by a hook of rounded limestone gravel, rising eight feet above the water: and extending northward is a gravel embankment, the pebbles in which become gradually coarser to a point just opposite the north end of the bay, where a thick bedded, tough and very vesicular dolomite is exposed for two feet above the water, having a dip 7° N. 70° W. [illegible] in all beds to the thickness of 6 feet 6 inches.

This same band of rock again appears on the shore a short distance south of Weston Point [illegible], there a dip of 5° to 5° in a direction S. 60° W. These [illegible] exposures belong to the Stromatopora zone of the Winnipeg formation and contain such typical fossils as *Stromatopora*

reticularis, Pentamerus conais, Stringocephalus Burtini, Paracyclas elliptica, Raphistoma Tyrrellii, Murchisonia turbinata and *M. Dowlingii* Winnipegosan fossils.

Half-way between these two exposures is a cliff showing five feet of white limestone dipping N. 55° W. at an angle of 3°, filled with Atrypas, &c., and representing the lower limestone of the Manitoban formation.

To the westward of Weston Point an island about half a mile in length extends nearly north and south parallel to the shore. Along its eastern side is a cliff ten feet in height of white thick-bedded limestone, the upper six feet being very compact and massive, while the four feet below are more friable, and break easily into irregular fragments. The bedding is almost horizontal, but undulates slightly. Weston Point Island.

On the north end of the island a cliff of similar limestone rises to a height of eight feet abruptly out of the lake, the beds dipping at an angle of 10° S. 40° W.

Both these exposures belong to the lower portion of the Manitoban formation and contain great numbers of *Atrypa reticularis* and *Atrypa aspera*, associated with such fossils as *Productella subaculeata, Spirifera fimbriata, Cyrtina Hamiltonensis, Pentamerus comis, Actinopteria Boydii, Modiomorpha tumida, Paracyclas elliptica, Bellerophon Pelops, Omphalocirrus Manitobensis, Loxonema altivolvis, Orthoceras Hindei*, and *Gyroceras submamillatum*. Manitoban fossils.

The shore from Weston Point to Red Deer Point is low, and fringed by a beach of gravel or boulders, behind which a meadow of greater or less width is usually found stretching back to a forest of spruce and poplar. East of Red Deer Point is South Marston Island, on the shores of which [illegible] exposures of Manitoban [illegible] which may be described in detail as follows.

Near the south-west [illegible] of the island, at the back of a [illegible] narrow gravel beach rising [illegible] height of two feet above the lake is a low cliff four feet high, of a white [illegible] containing such fossils as *Atrypa* [illegible] *sis, Paracyclas elliptica, Bellerophon* [illegible] It is almost [illegible] and [illegible] dip to the south-east [illegible] six feet of strata in the cliff.

Opposite this point, but on the east side of the island, similar cliffs seven feet in height expose in all nine feet of the same white thick-bedded compact limestone. The rock strikes along the shore in a direction N. 15° W. and dips S. 75° W. at angles varying from 18° to 24°, varying a little in direction with slight irregularities in the strike. It also contains numerous fossils of the same species as those at the previous

South Manitou Island. (Contd.)

locality, though with them are also found *Bellerophon Pelops* and *Cyathophyllum vermiculare*.

North of this cliff the shore is strewn with boulders for a short distance, and then a beach ridge of limestone gravel forms a long sweeping curve in front of a low meadow to the north-east point of the island, which is piled ten feet high with large round water-worn boulders of gneiss.

North end.

Half a mile west of this point, on the north side of the island, a light anticline with a strike N. 45° W. brings white limestone, similar to that last seen, three feet above the water, and from here westward, for a distance of about 600 paces, to the north-western angle of the island rock in low cliffs is more or less continuously exposed. It is very much

Small faults.

tilted and broken by small faults, but the beds at the west end of the beach are of the same age as those at the east end. The strata consist at the bottom of twelve feet of thick-bedded white limestone similar to that last seen. From it the following fossils were obtained, viz.: *Cyathophyllum vermiculare*, var. *præcursor*, *Alveolites* like *cryptodens*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *Spathella subelliptica*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Loxonema altivolvis*, *Hyotithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, *Gyroceras submamillatum*, and *Aspidichthys notabilis*. This limestone is

Red and yellow argillite.

seen to be conformably overlaid in places by at least six feet of pink-tinted irregularly fractured very calcareous argillite more or less compact and lying in beds of varying thickness. In one place also a bed of yellow and much fractured, thick bedded calcareous argillite, or argillaceous limestone, very similar to that outcropping at the southern exposure near Weston Point, is let down by a small fault against the underlying limestone. This bed may overlie the pink argillite, and its position is probably close above the six feet of strata recorded. Five feet of these yellow beds were seen. No fossils were seen in the argillaceous zone except a few fragments of small crinoid stems. (See Fig. 4 plate).

Beyond South Manitou Island the shores of Sagemace Bay, and the lake to near north latitude 52° 40′, are low and no exposures of the underlying rock could be found.

Birch Island.

Birch Island also has a shore very similar in character, except at its north-eastern extremity, where a little vertical cliff of Devonian dolomite, several hundred paces long looks out over the lake across a shelving beach of rounded pebbles. The top of the cliff at its highest point is level and ten feet above the water. There is here exposed in all twelve feet of yellow argillaceous dolomite in nearly horizontal beds from two to eight inches in thickness, but often broken by fractures to

North End, South Manitou Island, Lake Winnipegosis
Horizontal Scale 160 ft. to an inch.
Vertical Scale 55 ft. to an inch.

Devil's Point, Lake Winnipegosis
Ancient cliff of porous dolomite, with red shale at water's edge
Scale: 40 feet to an inch.

such an extent that the stratification is greatly obscured. The rock is porous and semi-crystalline, and often traversed by holes or cavities which at one time probably held fossils which have since been dissolved, and the only fossil found was a specimen of *Pentamerus comis*.

This rock usually weathers with a rough irregular knobby surface that is locally characteristic in any places where the rock is not subjected to much wear.

This Birch-Island dolomite is the lowest series of beds that have been definitely determined in Manitoba to be of Devonian age, but between them and the underlying Silurian there is a gap probably representing from fifty to a hundred feet of strata that have not yet been seen, and the country where these rocks would have been supposed to outcrop is now covered by the north-eastern portion of Lake Winnipegosis.

Hill Island.

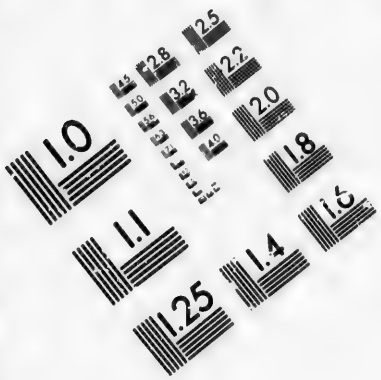
On Hill Island, a cliff rises at its northern end to a height of twenty feet above the top of the sloping beach of gneiss boulders, or about twenty six feet above the surface of the lake. The cliff is behind a belt of large spruce and poplar, is not now being actively worn by the waves, and is much covered by debris, but twelve feet of the thick-bedded horizontal porous semi-crystalline dolomite was measured. South of the cliff is a tail deposit of till with striated pebbles, and on the sloping surface of this till are two deposits of rounded gravel representing stages in the recession of the water of the lake, one twelve, and the other twenty-two feet above the present surface of the lake.

Proceeding north-westward from the cliffs on Birch Island, the presence of the same beds is indicated in North Manitou Island, where large angular masses are scattered over the heap of boulders of gneiss. Similar rock is also shown to outcrop on, or in the vicinity of a hill north-west of Fox Point, where a ridge with a crest twenty-eight feet above the lake is largely composed of rounded masses of similar porous massive granular dolomite, in which, however, a few fossils were found, consisting of *Atrypa reticularis*, *Atrypa aspera*, *Actinocystis variabilis*, *Productella subaculeata*, crinoid stems, &c.

Fox Point.

Pemmican Island.

On the east side of Pemmican Island there is a cliff forty feet in height, situated like many of the other cliffs in this portion of the lake, behind a row of trees that here consist of poplar, elm and maple. On the top is eight feet of limestone gravel in a sandy matrix, below which is exposed sixteen feet of yellow, granular horizontal Birch Island dolomite, as in most of the other places, it appears to be unfossiliferous. From the base of the exposed cliff, sixteen feet above the water, the shore is generally covered with boulders and small stones, but under these is a compact red clay, not improbably representing



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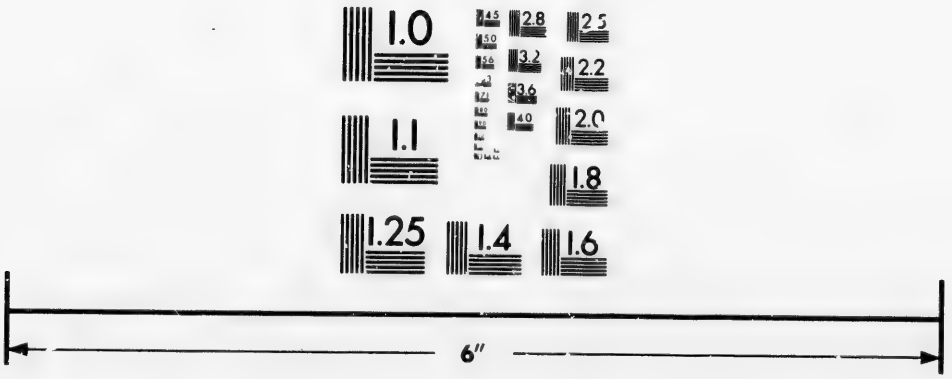

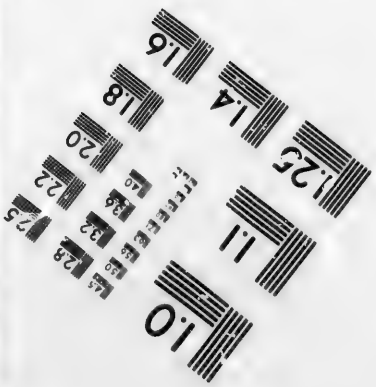

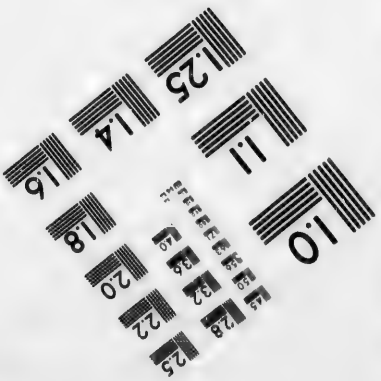

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Pemmican Island. (Contd.)

the outcrop of a bed of soft red argillite that may form the terrane underlying the Birch Island dolomite, and if this be the case the ease with which it would yield to eroding agencies would account for its general absence in natural sections.

Lignite.

On the beach are also scattered a number of fragments of lignite, and concretionary nodules of Marcasite, but the former, and probably also the latter, are undoubtedly of Cretaceous age, and would seem to be derived from an outlier of Dakota sandstone deposited in a hollow of the Devonian rocks and protected by the shelter of the cliff from destruction in either glacial or preglacial times.

A low outcrop of rock, probably slightly higher than that on Pemmican Island, occurs on the west shore of the lake in latitude 52° 45′.

Devils Point.

But the most interesting and instructive exposure of the rocks of this series is found on the west side of Devils Point, where a red clay, similar to that on Pemmican Island, makes its appearance in places close to the edge of the water, and on the beach are lying a number of spherical nodules of marcasite. The lowest beds definitely seen in place, however, are slightly undulating white porous and vesicular dolomites, regularly bedded, and containing a large number of fossils. These white dolomites are seen to have a thickness of three feet, and are probably immediately underlaid by red argillites. The following is a list of the fossils obtained from this band: *Atrypa reticularis*, *Pentamerus comis*, *Productella subaculeata*, *Orthis Manitobensis*, *Streptorhynchus Chemungensis*, *Spirifera Richardsonii*, *Modiomorpha parvula*, *Macrodon pygmæus*, *Anodontopsis affinis*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Cypricardinia planulata*, *Dentalium antiquum*, *Bellerophon Pelops*, *Straparollina obtusa?*, *Loxonema gracillum*, *Hyolithes alatus*, and *Proetus mundulus?*

Conformably overlying this white dolomite three feet of yellow porous dolomite is exposed, weathering with a rough nodular surface and apparently devoid of fossils. Above this, eleven feet is covered by beach deposits and debris fallen from the cliff, which is hidden behind a row of poplars. This cliff shows twelve feet of the rough yellow porous unfossiliferous dolomite in horizontal beds, overlaid by one foot of limestone gravel. From the summit of the cliff the land rises gently for a short distance and then more rapidly to the summit of a gravel ridge forty-five feet in all above the water. The whole of the surface is underlaid by more or less water-worn fragments of the limestone of the cliff.

Grand Island.

Crossing the strait to the west side of Grand Island, a cliff is also found within the edge of the timber, rising to a height of fifty feet above the water. The face of the cliff is for the most part covered with

slides and overgrown with bushes, but at its foot red clay forms a considerable portion of the shore, indicating the presence of the red argillite; the top of the cliff is composed of twelve feet of rough yellow porous dolomite, apparently quite unfossiliferous. On its summit is a gravel ridge at an elevation of fifty-five feet above the water.

Cormorant Islands.

On the east side of Cormorant Island a number of rounded nodules of marcasite are scattered among the gneissic boulders, having doubtless been ploughed up by the glacier from some outlier of the red argillite in the vicinity.

Island off Channel Island.

The last place at which this band was definitely recognized was on the eastern side of a small island lying east of Channel Island, where the ice has shoved up a large number of irregular angular fragments from the parent bed just beneath the surface of the water. It is here a rough yellow porous dolomite, the same as the higher beds at Devils Point, and like them appears to be entirely unfossiliferous.

Lying west-south-westward from the line of outcrop of the Birch Island dolomites is a belt of country, from twelve to fourteen miles in width, that lies a little higher than the country on both sides of it and possesses a much larger land area. On this higher belt rock exposures are almost entirely absent, the surface being more or less completely covered with till. The higher portion of the Winnipegosan horizon is, however, indicated by the presence of unworn pieces of dolomite, with fossils already recorded, on a small island south-east of Birch Island, and exposures of the lower portion of the Manitoban limestone are seen on the west sides of Pelican and Cameron bays. The former exposure is in latitude 52° 44′ 30″ and consists of a cliff extending 200 paces along the shore and rising twenty-six and a half feet above the water. The rock is brought up by a low anticline striking N. 10° E. and forms a ridge that can be followed for some distance into the woods. The upper six feet is a white slightly argillaceous limestone containing a large number of *Atrypa reticularis*, *Atrypa aspera* and *Paracyclas elliptica*, and a few specimens of *Bellerophon Pelops*, *Pentamerus conis* and *Proetus mundulus?* Below this is a yellowish and much more friable limestone, breaking into angular fragments, and apparently unfossiliferous.

Pelican Bay.

Cameron Bay.

The other exposure is on the west side of Cameron Bay, where a cliff rises thirty-seven feet above the surface of the lake. It is almost hidden behind a narrow belt of poplar growing on a gentle slope, which, at a height of eleven feet above the water, is piled with nine feet of irregular rock debris. Above this rises an almost vertical wall for fifteen feet, composed of light buff argillaceous limestone. It is horizontally and evenly bedded, is compact and even-grained, and breaks

regularly when struck with the hammer, the beds being very sonorous. It is very similar to the rock seen on the shore of Red Deer Peninsula, three miles south of Weston Point, and to some of the rock at Point Brabant on the east shore of the lake and represents the base of the Manitoban formation.

The lowest beds exposed in the cliff, for a thickness of three feet are very fossiliferous, and contain a great number of *Atrypa reticularis*, and crinoid stems, associated with *Cyathophyllum Athabascense*, var., *Productella subaculeata*, *Cyrtina Hamiltonensis*, *Atrypa aspera*, *Kejersteinia subovata*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, and *Proetus mundulus*. The upper beds also contain a few similar fossils scattered through them, but not in any great abundance. The foot of the cliff is springy, and the water flowing from it is quite fresh.

Line of low country.

West-south-west of the belt of slightly higher land, which appears to be a more or less irregular broad synclinal trough, is another linear area eroded out into rather deep hollows, which on the map can be traced through the western and north-western arms of Lake Manitoba, through the open part of Lake Winnipegosis between Red Deer Point and Birch Island, and onward through Pelican Lake and Dawson bays. This area contains by far the greatest number of rock exposures in the whole district. Those in the most southern portions have already been described, and while several were reported on Pelican Lake, it was found impossible to visit them. Those on Dawson Bay therefore alone remain to be described, and on account of the irregular and almost unconnected character of the outcrops it will be impossible to describe them otherwise than in geographical succession.

Dawson Bay.

Island north of Whiteaves Point.

Beginning on the east side of the bay the most conspicuous feature is an island a mile and a half north of Whiteaves Point which rises abruptly out of the lake. On the west side of this island the waves beat against the foot of a vertical cliff of white dolomite that overlooks the lake, with a total height of forty-one feet. Its summit is rough and broken, and apparently water-worn, with a covering of moss along the front, while further back, where the surface is two or three feet higher, it is covered with a thick growth of choke cherry, ash-leaved maple, &c. From here the surface declines to the east side of the island, and at length drops in a low cliff to the water. Towards the south the surface slopes gradually to the water's edge and the island termi-

nates in a bar of irregularly rounded gravel extending towards the south-west.

The cliff, shown on the plate in front of this report, is composed of a very thick-bedded or massive white exceedingly tough dolomite, occasionally somewhat crystalline, but never harsh or rough. The bedding is not always distinctly marked, but the hill is clearly shown to be brought up by a rather sharp anticline with a strike S. 85° W., and the rock dips off towards each end at angles varying from 25° to 30°. In the middle of the cliff, where the stratification is horizontal, thirty-nine feet of rock in all are seen. The rock is cut by numerous jointage planes that run from the top to the bottom of the exposure. A number of faults have occurred along these jointage planes, so that it is difficult to measure the exact thickness of beds exposed. If these faults were left out of account, the total thickness of strata, here seen, would be 100 feet, but it is doubtful whether a much greater thickness is brought under observation than the thirty-nine feet occupying the middle of the cliff. The thickness of beds exposed may, however, amount to fifty or sixty feet. Cliff of dolomite.

The lowest beds, about ten feet in all, are not so thick-bedded as the rest, break down more readily, and contain a large number of stems of Crinoids. Above this are ten feet rather barren of fossils, and then there is a very massive band from which large angular masses have fallen and are lying at the foot of the cliff. This band is rather rich in fossils, and from it the following species have been collected: *Spharospongia tessellata, Favosites Gothlandica, Pachypora cervicornis, Alveolites* like *cryptodens, Stromatopora Bücheliensis, S. Hüpschii, Ctenocrinus* sp., *Spirorbis omphalodes, Pinacotrypa marginata, Cystodictya Hamiltonensis, Fenestella vera, F. dispanda, Polypora Manitobensis, Productella subaculeata, Orthis Manitobensis, Streptorhynchus Chemungensis, Strophodonta interstrialis, Strophodonta arcuata, Spirifera fimbriata, Atrypa reticularis, Pentamerus comis, Stringocephalus Burtini, Terebratula Sullivanti, Actinopteria Boydii, Nucula Manitobensis, Dentalium antiquum, Pleurotomaria Spenceri, Euomphalus annulatus, Platyceras parvulum, Orthoceras Tyrrellii, Gyroceras filitextum, Isochilina Dawsoni, Elpe Tyrrellii, Bronteus Manitobensis, Cyphaspis bellula,* and *Proetus mundulus.* Fossils.

Whiteaves Point is a cliff twenty-one feet in height extending for a mile along the shore, and rising to a total height of thirty-one feet above the water. In front of it is a strip of land fifty feet in width wooded with fine large elms, between which and the water is a low beach of irregular fragments of limestone. The summit of the cliff is rather rough and wooded with small poplar. Whiteave Point.

The rock is a white compact, uncrystalline, dolomite not very thickly or evenly bedded, but breaking readily into irregular fragments. Though the stratification is essentially horizontal, it is cut by numerous jointage planes, along which the rock appears to have slidden to some extent. It probably represents the highest beds seen at the island just described, or possibly beds somewhat higher.

In places it contains a large number of beautifully preserved fossils, among which the most common and conspicuous are *Stringocephalus Burtini*, *Orthoceras Tyrrellii* and *Gyroceras Canadense*. With these are associated many of the species found at the small island, and in addition the following species : *Cyathophyllum Anna*, *Actinocystis variabilis*, *Actinostroma Tyrrellii*, *Atrypa aspera*, *Pterinea lobata*, *Modiomorphă attenuata*, *M. compressa*, *Conocardium Ohioense*, *Cardiopsis tenuicostata*, *Orthonota corrugata*, *Pleurotomaria goniostoma*, *Murchisonia Dowlingii*, *Bellerophon Pelops*, *Ennema brevispira*, *Astralites fimbriatus*, *Omphalocirrus Manitobensis*, *Naticopsis inornata*, *Hyolithes alatus*, and *Homaloceras planatum*.

Islands south-west of Whiteaves Point.

South-west of Whiteaves Point are a number of lovely wooded islands rising out of moderately deep water, on several of which exposures of dolomite and limestone are to be seen. The first of these lies a little more than a mile from the point, on the north end of which is a hill twenty feet in height. This hill is largely covered with an herbaceous growth, but an irregular rocky knob shows it to be composed of cream-white dolomite containing a great number of masses of *Actinostroma expansum ;* and at the edge of the water is a more or less thin and regularly bedded hard white dolomite, poor in fossils, though containing some very large stems of Crinoids. The stratification appears to be essentially horizontal, though the more massive portions in the hill are much shattered, probably by a small fault, so that it is difficult to detect any stratification. Large Crinoid stems and the tail of a *Proetus* were found in these beds.

The shore on the north end consists of fragments of dolomite broken by the ice from the rock immediately below it, behind which are rough irregular masses fallen from the crag. The rest of the island is surrounded by a beach of more or less rounded fragments of dolomite entirely or almost entirely derived from the rock of the island itself, and containing the following fossils, viz. : *Sphærospongia tessellata*, *Cystiphyllum profundum*, *Favosites Gothlandica*, *Pachypora cervicornis*, *Cystodictya Hamiltonensis*, *Polypora Manitobensis*, *Orthis Manitobensis*, *Strophodonta interstrialis*, *Spirifera fimbriata*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Myalina inflata*, *Macrodon pygmæus*, *Orthonota corrugata*,

Pleurotomaria Spenceri, Eunema speciosum, Omphalocirrus Manitobensis, Straparollina obtusa, Platyceras parvulum, Macrochilina subcostata, Brontens Manitobensis, and *Cyphaspis bellula.*

A mile further west lies a somewhat larger island, on the north-west side of which an abrupt vertical cliff of light grey dolomite, with a slightly porous and semi-crystalline texture, rises to a height of forty-three feet above the water. It is eaten out by the waves to a height of ten feet, and above is covered with light brown lichen. The foot of the cliff is covered with large angular blocks fallen from its face, while the summit is overgrown with grass and small sage-bush.

The rock is brought up by a rather sharp anticline with a strike N. 40° E. At the eastern end is a fault with a dip of 40° striking N. 35° E., and with a throw to the north probably of about ten feet. West of this the rock rises with a dip of 27°, which rapidly lessens till in the middle and highest part of the cliff the stratification is practically horizontal. To the south the beds are cut off abruptly by a fault, south of which for seventy-five feet the beds are very irregularly disposed, and beyond which they disappear. There would appear to be a light throw to the south in this latter fault. Anticline.

In the middle of the cliff the lower beds are white dolomite, thinly and more or less irregularly bedded, and apparently not containing many fossils. Above this is a similar but thick-bedded dolomite containing numbers of *Actinostroma fenestratum.* The broken dolomite to the south of the fault is of a slightly yellow colour, and from it the following fossils were obtained: *Sphærospongia tessellata, Actinocystis variabilis, Favosites Gothlandica, Pachypora cervicornis, Alveolites vallorum, Ctenocrinus* sp., *Atrypa reticularis, Pentamerus comis, Stringocephalus Burtini, Terebratula Sullivanti, Pterinea lobata, Myalina inflata, Goniophora perangulata, Pleurotomaria Simpsoni, Murchisonia turbinata, M. Dowlingii, Porcellia striata, Eunema speciosum, Euomphalus annulatus, Omphalocirrus Manitobensis, Straparollina obtusa, Pseudophorus tectiformis, Loxonema cingulatum, Cyrtoceras occidentale, Gyroceras Canadense, Cyphaspis bellula,* and *Proetus mundulus.*

To the west of this island lie two other small islands thickly wooded with elm and poplar. Both are low and no rock is seen on them in place, but on the north side of the larger one the pebbles are angular, and little, or not at all, rounded by the water, and would appear to have been shoved up by the ice from a bed of rock beneath the surface of the water. Behind the beach they are piled into a high ridge by the ice. These pebbles consist of white dolomite like the last, and contain quite a large number of the same fossils. On the east side of the island the Islands of pebbles.

pebbles are much more rounded, and are piled in a ridge ten feet in height by the combined action of waves and ice.

A mile south of the last rocky island is a larger island on the north-east side of which is a vertical cliff twenty-five feet high from top to bottom, the latter being some distance back from the then level of the water and about two feet above it. The crest of the hill is three feet above the brow of the cliff and is wooded with small poplar. The rock is a cream-white vesicular dolomite, and in places appears to be largely made up of *Actinostroma fenestratum*, *Actinostroma Tyrrellii* and *Stromatopora Bücheliensis?* Besides these, twenty-three other species were collected similar to those found at the previously described exposures in the bay, and characteristic of the Stringocephalus zone. The bedding in several places appears to be approximately horizontal, but it is cut by several jointage planes along which slight faults have occurred. It is impossible to say how much rock is exposed, but possibly not much more than twenty-five feet.

Beardy Island.

Adjoining this island is a large boot-shaped island, the largest island in the bay, known as Beardy Island. On its south shore, close to the margin of the lake, a soft, cream-coloured, porous, saccharine dolomite is seen apparently in place, and large angular blocks of the same dolomite are piled on the shore. It is thick and more or less irregularly bedded, and the only fossil detected was a large nodose Stromatoporoid. This bed would appear to represent the top of the Winnipegosan series, for on the opposite side of the island, and but a short distance away, a hill rises to a height of twenty feet, on the face of which, just within the edge of the woods, is a cliff sixteen feet in height. This cliff, and the gently sloping beach of shelving rock at its foot is composed of thin-bedded white argillaceous limestone containing a large number of *Atrypa reticularis* and *Atrypa aspera*, associated with the following other fossils, viz.: *Paracyclas elliptica*, *Kefersteinia subovata*, *Raphistoma Tyrrellii*, *Porcellia Manitobensis*, *Enomphalus subtrigonalis*, *Hyolithes alatus*, crinoid stems, and *Cyathophyllum Waskasense*. The bedding is nearly horizontal, and the rock overlies the harsh dolomite seen on the south side of the island and represents the lower portion of the Manitoban series.

Turning now into the bay south-west of Beardy Island, the south shore is generally low and scattered with irregular fragments of limestone and dolomite, while long bars composed of similar pebbles run out into the shallow water.

Near Bell River.

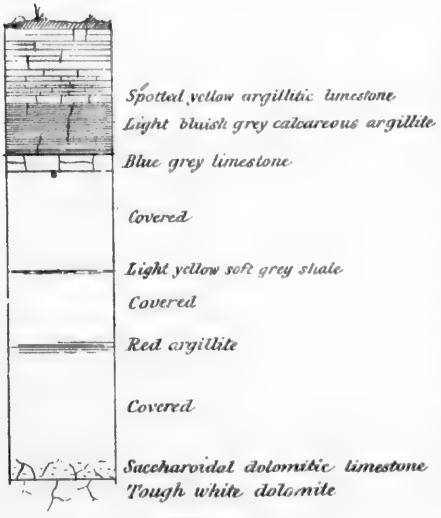
Towards the west end of this shore, and a mile east of the mouth of Bell River, a cliff from twenty to twenty-five feet in height extends for a quarter of a mile within the edge of the woods, but so much debris

has fallen and covered its face, and it is so thickly overgrown with trees and bushes that it is difficult to determine accurately the thickness of the beds composing it. However, the following characters were observed. The hill is caused by the bulging up of the rock shown by a light dip away from the centre in three directions, while the lake has cut across the front and obscured the dip that may exist towards the north.

Argillaceous limestone.

At both ends of the cliff the upper beds are composed of light gray slightly argillaceous limestone containing a large number of *Atrypa reticularis* and *Atrypa aspera*, associated with *Spirifera Richardsonii*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Euomphalus subtrigonalis*, *Loxonema altirolvis*, *Hyolithes alatus*, *Actinoceras Hindii*, and *Alveolites Rameri*. These represent the beds seen at Beardy Island, and eight feet or more are here exposed. They are underlaid by seven feet of a rather soft light bluish-gray calcareous argillite, in which are little masses of soft hematite, possibly caused by the decay or alteration of crystalline aggregates of pyrite. The argillite is cut by occasional veins of finely crystalline calcite, and towards the bottom contains a few nodules of hard limestone, while a foot at the top is generally harder than the rest. It appeared to be quite unfossiliferous. Its exposed face is weathered with smoothly rounded contours, and the debris falling from this portion of the cliff breaks into thin shaly fragments.

Contact of Manitoban and Winnipegosan Formations near the mouth of Bell River.



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This band is underlaid by two feet or more of a light bluish-gray unfossiliferous limestone.

Below this, the section is obscured for twelve feet by slides and vegetation, and then a light yellow soft gray clay is seen cropping from the side of the bank. It is again covered for nine feet, and then there is a slight exposure of a rather soft red calcareous argillite.

Below this outcrop of red argillite the hill is covered by debris for sixteen feet to the top of

the low beach, where a yellow, saccharine, porous dolomitic limestone makes its appearance for a short distance, and from which flow springs of strong brine.

Below the saccharine dolomitic limestone, and right on the margin of the lake is a light brown or almost white, very slightly crystalline and tough dolomite. It is generally compact, but in some places is slightly porous, while in others it shows little rectangular cavities left by the solution of tabular crystals of salt. This dolomite did not appear to contain any fossils, but it and the saccharine dolomitic limestone undoubtedly represent the top of the Winnipegosan formation, while the argillite above represents the base of the Manitoban.

Contact of Manitoban and Winnipegosan formation.

On a long point, a mile further towards the north-west, a low exposure of rather granular vesicular dolomite of the Winnipegosan formation outcrops with a dip of 5° S. 35° W., and behind it the point is heaped high with irregular fragments which have doubtless been recently broken from the rock, and shoved up by the ice. These contain a few fossils, such as *Pentamerus comis*, *Stringocephalus Burtini*, *Eunema brevispira*, &c. Proceeding S. 30° W. down the shore for 500 feet, white, friable, argillaceous limestones holding *Atrypa reticularis*, *A. aspera*, *Bellerophon Pelops*, *Hyolithes alatus*, &c., make their appearance dipping S. 75° W. 25°, and from this point they form a low cliff a little back in the woods, running southward for a quarter of a mile parallel to the shore, where it flattens out. These represent the several beds recorded in the section on the preceding page.

On the opposite side of the little bay at the mouth of Bell River, a hill rises to a height of 100 feet above the water, and across the end of this hill the waves have cut a cliff thirty feet high. The upper twelve feet of this cliff is composed of white, friable limestone, the same as that outcropping across the bay. It contains the following fossils: *Atrypa reticularis*, *Spirifera Richardsonii*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Gomphoceras Manitobense*, *Favosites Gothlandica* and *Alveolites rallorum*.

For eighteen feet below this, in the middle of the anticline, the section is covered with debris and overgrown with brush.

A light dip carries the beds up and back from the face of the cliff, but the beds on the top of the hill are still a little higher and are composed of hard gray limestone containing a large number of *Atrypa reticularis*, *Atrypa aspera*, and *Paracyclas elliptica*.

Two miles and three-quarters north of the mouth of Bell River is a bare flat, over which a small brook flows into the lake, behind which

are some ridges of impure sand. The creek when examined on the 1st of August, 1889, was flowing sixty gallons a minute and the water was very saline, containing about six-sevenths of a pound of common salt to the gallon, which would give a total discharge by the brook of about thirty-seven tons of salt every twenty-four hours. The summer of 1889 was a particularly dry one and during ordinary seasons, with an average amount of rainfall, the brine would doubtless be somewhat weaker, but on the other hand the quantity of brine discharged and probably of salt also would be greater. This brook flows from several springs a mile or more further inland, which are described elsewhere. Brook of salt water.

A mile east of the mouth of the briny creek, on the west side of a point, is a low exposure of from fifteen to twenty feet of white porous and vesicular dolomite dipping N. 70° E. at angles varying from 0° up to 12°. It contains a few characteristic Winnipegosan fossils, and a small amount of brine is flowing from it. On the east side of the point a low anticline forms a hill thirty feet in height, the rock dipping southward at an angle of 15° and northward at an angle of 3°. The bottom beds are hidden by debris, but at the top twelve feet are seen consisting of gray limestone containing fossils, overlying nine feet of evenly bedded, light yellow limestone holding a few Atrypas, which again overlies a light blue-gray shale. The fossils in the upper band consist of *Cyathophyllum Anna*, *Atrypa reticularis*, *Atrypa aspera*, *Productella subaculeata*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Hyolithes alatus*, and *Gyroceras Canadense*. Point north of Bell River.

North and east of this cliff the shore is generally low and the land behind it rises gently to a few feet above the water. In some places a wall of boulders lines the shore. No rock is seen in place, but brine springs rise to the surface, apparently through a light covering of till, and many of the boulders and masses of rock in this vicinity are composed of Stringocephalus dolomite.

Three miles north of Salt Point, an island about a mile in length, and of a somewhat oval shape, rises conspicuously out of the lake. The south and west shores of this island are composed of well rounded water-worn pebbles of dolomite, while to the north, and hidden behind a belt of trees, is a rather broken cliff twenty feet high composed of a thick and thin-bedded, coralline, dolomitic limestone cut by a number of jointage planes generally at a high angle to the horizon. The rock appears to be brought up by a light anticline and in places is composed largely of *Cyathophyllum profundum*. With this are associated *Sphærospongia tessellata*, *Pachypora cervicornis*, *Alveolites vallorum*, *Actinostroma Tyrrellii*, *Fenestella vera*, *Polypora Manitobensis*, *Atrypa* Island north of Salt Point

reticularis, *A. aspera*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*. *Eunema brevispira*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Naticopsis inornata*, *Macrochilina subcostata*, and *Proetus mundulus*.

This evidently represents a portion of the Winnipegosan formation, and probably is at the base of, or just below the bottom of the Stringocephalus zone

Salt Point.

Returning to the north shore of Salt Point Peninsula and proceeding westward, the first exposure is a cliff thirty feet in height, which consists of white dolomite dipping a little west of south at an angle of 5°. At the water's edge it consists of a tough, white, yellow-weathering, thick-bedded dolomite, in which are many pores and vesicles surrounded by light brownish stains. The surface of the individual beds is very irregular, and in them *Actinostroma Tyrrellii* and *A. fenestratum* are very abundant, along with many other fossils. Overlying the beds above described there are fourteen feet of very similar dolomites, about the middle of which is a band containing a large number of *Kefersteinia subovata*. Besides the above, these rocks contain the following fossils, characteristic of the Stringocephalus zone of the Winnipegosan formation, viz.: *Spharospongia tessellata*, *Columnaria disjuncta*, *Pachypora cervicornis*, *Alveolites vallorum*, *Actinostroma Tyrrellii*, *A. fenestratum*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Gosseletia* sp., *Myalina inflata*, *Modiomorpha compressa*, *M. parvula*, *Goniophora perangulata*, *Nucula Manitobensis*, *Kefersteinia subovata*, *Paracyclas antiqua*, *P. elliptica*, *Conocardium Ohioense*, *Cardiopsis tenuicostata*, *Cypricardella bellistriata*, *Dentalium antiquum* (?), *Pleurotomaria goniostoma*, *P. infranodosa*, *Raphistoma Tyrrellii*, *Murchisonia turbinata*, *M. Dowlingii*, *Eunema speciosum*, *E. brevispira*, *E. subspinosum*, *E. clathratulum*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Pseudophorus tectiformis*, *Naticopsis inornata*, *Macrochilina subcostata*, *M. pulchella*, *Hyolithes alatus*, *Orthoceras Tyrrellii*, *Tetragonoceras gracile*, and *Proetus mundulus*. Above these fossiliferous beds the strata become thinner and much more compact to the top, where, for three feet, they are very resonant and appear to be destitute of fossils.

Half a mile farther west, is a bare cliff fourteen feet in height, consisting of a white or cream-coloured, tough, uncrystalline dolomite with a great number of small vesicular cavities, and containing very many beautifully clear crystals of calcite. It also contains many concretions, which in places are very small, and give the rock quite a pisolitic

appearance. This is overlaid by a bed of hard argillaceous limestone. These beds dip with considerable regularity S. 60° W. at an angle of 3°.

Behind the point formed by this projecting cliff, a hill rises to a height of seventy feet above the lake, and in a bay to the west, where this higher hill approaches close to the shore, the top of the porous dolomite outcrops on the beach. The section shown on the face of this hill is as follows in descending order : Hill west of Steep Rock River.

	ft.	in.
Light gray thick-bedded argillaceous limestone, holding *Atrypa reticularis*, *A. aspera*, and *Paracyclas elliptica* in great abundance, associated with other species common to the Manitoban formation	12	0
A very compact, fine-grained, hard, brittle buff-coloured limestone	1	6
A light bluish-gray, soft, fine-grained calcareous argillite, breaking down into a gray shale	3	0
Brownish-gray, hard, finely crystalline argillaceous limestone, through which run veins of crystalline calcite	4	0
Covered	8	0
Similar hard argillaceous limestone	3	0
Covered	36	0
Hard argillite	2	
Porous white dolomite		

A mile and a half further west a cliff rises to a height of twenty-four feet above the water, composed of tough, white, vesicular dolomite containing *Stringocephalus Burtini* and other associated fossils ; and just at the point in which this cliff terminates, a grassy hill rises in a steep slope to a height of forty feet above the lake, and from the top, and sides of this hill flow several brine springs, aggregating in all about twenty-five gallons a minute.

At a salient point still further west, and just opposite the mouth of Steep Rock River, is a cliff of similar tough, white, vesicular dolomite, the little cavities being arranged in horizontal layers and containing a few fossils, such as *Pentamerus comis*, &c.

This cliff is twenty-four feet in height and is overlaid by a coarse saccharine dolomite, while at the foot of the cliff the rock contains *Stringocephalus Burtini* and a large number of fossils generally associated with it.

About the middle of the exposure, a slight anticline brings a light brown argillaceous and slightly crystalline dolomitic limestone just above the surface of the water. It breaks readily with a very uneven, jagged fracture, and contains a few fossils, among which are *Atrypa reticularis* and *Spirifera fimbriata*.

Steep Rock River.

Crossing the little bay to the west, and ascending Steep Rock River for about half a mile from its mouth, a thin and evenly bedded, light brown, argillaceous limestone of the lower portion of the Manitoban formation outcrops in the bottom of the brook and for a few feet up the side of this bank with a light north-westerly dip.

Portage.

Leaving the river at this point a portage strikes off towards the south-west and passing through a poplar forest for a mile and a quarter again reaches the river in a wide marsh. Towards its western end it passes over a rocky hill that rises 100 feet above the lake, on the sides of which are several low exposures of a coarse-grained, crystalline, mottled white and brown limestone. No fossils were found in it, but it doubtless belongs to the Manitoban formation. The limestone lies in thick horizontal beds which are cut by a number of veins of crystalline calcite, and has much the appearance of some of the bands of limestone below the Atrypa band. It is possible that it has here replaced the shale to a considerable extent.

Hill north of Steep Rock River.

North of the mouth of Steep Rock River a hill rises to a height of eighty feet, with a smoothly rounded top composed of thin-bedded, horizontal, light gray Manitoban limestone, holding *A. reticularis*, &c., while twenty feet below it a spring of brine flows from the side hill and forms a barren, sterile band to the bottom of the slope. Irregular fragments of Winnipegosan dolomite are lying about, evidently derived from the immediate vicinity.

Also three-quarters of a mile north of the mouth of Steep Rock River a hill fifty-five feet in height forms a salient point projecting into the lake. On its summit are ten feet of horizontal, white, or light yellowish-gray limestone, containing a number of typical Manitoban fossils, including *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Hyolithes alatus*, &c. This is underlaid by a light gray or greenish-gray, calcareous argillite which appears to have a thickness of twelve feet or more, and below this the hill is covered to the bottom. At the north end of the hill these rocks have a dip of 20° S. 10° W. At the edge of the water is an irregularly bedded, rather coarse-grained, saccharine limestone, dipping at about 5° from N.E. to E. In places it is pure white and in other places it is of a dark brownish colour, and through it rise a number of springs of brine.

Half a mile further north a similar hill rises to a height of thirty-five feet above the lake, on the summit of which are twelve feet of typical light greenish-gray Manitoban limestone in beds of varying thickness and containing a large number of characteristic fossils. Below it is a calcareous argillite in thin beds.

Leaving the bay into which Steep Rock River empties, and coasting northward beside a long gravel spit, a hill is reached rising to a height of forty feet above the water, its lakeward face being now for the most part overgrown with bushes, and separated from the pebbly beach by a narrow belt of trees. The rock throughout is a light gray, thick-bedded, friable limestone which in places is oolitic and contains many comminuted fragments of fossils, but the only fossils that could be recognized were *Atrypa reticularis*, *Athyris vittata* and *Cypricardinia planulata*. The rock is undoubtedly the same as the upper beds at Point Wilkins, described below.

Point Wilkins

Two miles further to the north the shore turns abruptly westward, and at the salient angle thus formed, Point Wilkins rises as a vertical cliff to a height of eighty-three feet above the lake, being the highest and most conspicuous promontory on its shore.

It consists of horizontal strata with the following characters, considered in descending order:—

Forty feet of light gray, very compact, fine-grained, thick-bedded, and in places oolitic limestone which breaks readily into polygonal fragments when struck with a hammer. Very few species of fossils were found in these beds, the most common being *Athyris vittata*, and with it are associated a few specimens of *Atrypa reticularis*.

Thirty-three feet of a light gray argillaceous limestone, running down into a hard, compact, sonorous limestone, interbedded with clay shale. This limestone contains, in places, beautifully preserved cubical crystals of pyrite, which disappear on weathering, leaving the surface pitted with small cavities. The argillaceous limestone and the shaly bands contain many beautifully preserved fossils, among which are *Atrypa reticularis*, *Cyrtina Hamiltonensis*, *Paracyclas elliptica*, *Euomphalus subtrigonalis*, *Gomphoceras Manitobense*, and *Ptyctodus calceolus*.

Ten feet of red calcareous argillite without fossils.

These beds represent the upper portions of the Manitoban formation as seen in this district, and although they were not seen in direct contact with the lower portion of the terrane, the red argillite at the base of the section probably lies not far above the limestone seen on the tops of the hills a little distance further south.

The highest part of the promontory is at its north-eastern extremity, from which the summit declines with a slope about a mile in length both to the south and west. The stratification is in general nearly horizontal, and the slope of the surface is formed by the unequal erosion of the beds.

Fissure breccias.

The strata, however, have been cut by vertical fissures in a number of places, and into these fissures the overlying and surrounding rock

has fallen in a confused and irregular mass. One of the most interesting examples of these broken strata occurs three-quarters of a mile south of the point, where the cliff is but eighteen feet in height and hidden behind a row of birch and poplar. For a distance of thirty-two paces along the shore the rock is very much disturbed, and projects thirty feet beyond the rest of the cliff, which consists on both sides of the lower argillaceous limestone lying quite horizontally. In the disturbed portion, however, the rock consists to a considerable extent of the upper limestone holding *Athyris vittata*, in fragments lying in every conceivable position. With this limestone is associated a hard, light blue sandstone composed of fine, more or less rounded grains of white quartz, of about equal size, with occasionally an included nodule of iron pyrites. This sandstone often forms the matrix of a breccia, in which are included the angular pebbles of brittle limestone.

This brecciated mass has undoubtedly been formed by the falling in of the overlying rock to fill a cave or fissure, and the presence of the Athyris limestone shows that this caving in took place before the surface was denuded down to its present level, since the cliff, to its summit, is now composed of the underlying argillaceous limestone, and the presence of the sandstone shows that this limestone was overlaid by a white or light blue sand, which would appear to have been the Dakota sandstone of the base of the Cretaceous, and which was sufficiently soft and incoherent to run down and fill the interstices between the fragments of limestone. This sand has since been converted into a hard sandstone by the infiltration of a calcareous cement.

Dakota sandstone.

About two hundred paces further north the rock in the cliff is again disturbed in a somewhat similar manner, but here there is no sandstone mixed with the limestone.

Half a mile still further north a mass of slidden limestone is standing like a buttress against the face of the cliff, which is here about seventy feet high. This cliff is depicted on page 67 of Dr. Spencer's Report. The beds, especially the upper ones, are but very little disturbed, and practically horizontal, while at the bottom are ten feet of evenly stratified red argillite. All are hidden for a short distance by the mass of limestone fallen from above. This has evidently been formed by the filling in of a cave from above, or of a fissure running parallel to the present face of the cliff, and on account of the inclined position of the rock, the waves of the lake, both at its present and during its higher stages, have not been able to wear it back as rapidly as the adjoining horizontal beds of the cliff, and thus it stands out as a salient feature on the face of the escarpment.

Buttress of broken limestone.

In other places in the same promontory the beds are similarly disturbed, but the instances already described are the most remarkable.

Mouth of Red Deer River.

From Point Wilkins no rock in place was seen on the shore for several miles, until a little peninsula was reached just south of the mouth of Red Deer River, where the beach is composed of dolomite dipping N. 85° W. at an angle of 10°. At the back of the beach, and at the edge of the woods of elm and willow, is a little cliff, a foot or so in height, of hard white vesicular Winnipegosan dolomite, and piled up in front of it, and hiding the cliff in many places, are fragments of the same rock containing *Sphærospongia tessellata, Pachypora cervicornis, Atrypa reticularis, Rhynchonella pugnus, Pentamerus comis, Stringocephalus Burtini, Myalina inflata, Kefersteinia subovata, Mecynodon* like *Eifeliensis, Cardiopsis tenuicostata, Cypricardinia planulata, Orthonota corrugata, Palæacmæa cingulata, Pleurotomaria goniostoma, P. infranodosa, P. Spenceri, Eunema brevispira, E. subspinosum, E. clathratulum, Astralites fimbriatus, Omphalocirrus Manitobensis, Macrochilina subcostata, Orthoceras Tyrrellii, Cyrtoceras occidentale,* and *Gyroceras filitextum.*

North of Red Deer River.

Two miles and a half north-east of the mouth of Red Deer River a slight and rather irregular anticline brings to the surface twenty feet of a thick-bedded, porous, yellow-weathering dolomite of the Winnipegosan series, containing a few very characteristic fossils, such as *Sphærospongia tessellata, Columnaria disjuncta, Amplexus* or *Diphyphyllum, Pachypora cervicornis, Alveolites vallorum, Discina* sp., *Orthis Manitobensis, Spirifera fimbriata, Atrypa reticularis, Pentamerus comis, Stringocephalus Burtini, Actinopteria Boydii, Myalina trigonalis, Modiomorphia parvula, Paracyclas antiqua, Pleurotomaria infranodosa, P. Spenceri, Eunema subspinosum, Straparollina obtusa, Naticopsis inornata, Gyroceras filitextum.*

Two miles further north a prominent point on the shore is formed of similar dolomite, also brought up by an anticline striking north and south. At the east end of the cliff the dip is eastward with an angle of 20°, while at the west end it is westward at a low angle. The rock contains *Stringocephalus Burtini* and many other fossils, the same as those found at the last point, besides which were *Polypora Manitobensis, Spirifera Richardsonii, Atrypa aspera, Spatella subelliptica, Dentalium antiquum,* and *Murchisonia Dowlingii.*

A mile and three-quarters west of this point and close to the shore, a hill of similar dolomite containing *Stringocephalus Burtini,* &c., rises to a height of twenty feet above the lake, and a mile to the north-west is another hill of very similar vesicular dolomite, which, however, did not appear to contain any fossils. Ten feet in all of

this dolomite was seen, and in a bed eight feet below the top are many little crystalline masses of pyrite, some of which have been altered into hematite. A beautiful cast of the exterior of a large salt crystal was also seen.

Below this bed of dolomite a gently sloping hill fifteen feet in height reaches to the lake, and over it are trickling several little rills of brine.

Macoun Point.

The only other exposure of rock in place, seen on the west shore of Dawson Bay is at Macoun Point, which is marked by a beautiful grove of tall spreading elms. Around the grove is a beach of rounded limestone gravel, and in front of, and a little below the gravel is a line of transported boulders of gneiss and limestone. From this line of boulders the shore extends with a gently declining slope to the edge of the water and is strewn with angular fragments of porous dolomite which have been shoved up by the ice from a bed with a very irregular surface, that makes its appearance in extreme low water in a few places. It consists of a thick-bedded, light brownish-gray, saccharine dolomite, so porous as to feel very light. It does not appear to contain any fossils, but closely resembles in general character the dolomite from Devils Point. It would seem to be an upward continuation of the Birch Island dolomite, probably immediately underlying the Stringocephalus zone.

Rowan Island.

Turning now to Rowan Island, which lies two miles and a half off the shore, in the north-western portion of Dawson Bay, its western extremity is found to be composed of a rough porous dolomite precisely similar to that at Macoun Point, and like it quite unfossiliferous.

Near the south point of the island this dolomite again composes the shore, while just back from the margin of the lake, a hill rises to the height of twenty feet and is composed of a white, thick-bedded, tough, vesicular dolomite, practically horizontal, and thus immediately overlying the hard porous dolomite. It would appear to represent the base of the Stringocephalus zone and contains a number of its typical fossils, such as *Sphærospongia tessellata*, *Actinocystis variabilis*, *Actinostroma Tyrrellii*, *A. fenestratum*, *Cystodictya Hamiltonensis*, *Fenestella dispanda*, *Spirifera fimbriata*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Goniophora perangulata*, *Bellerophon Pelops*, *Porcellia Manitobensis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *L. priscum*, *L. cingulatum*, *Bronteus Manitobensis*, and *Lichas (Terataspis)* sp.

For the rest the island appears to be composed of these two kinds of dolomite, though at the north end, where low hills occur, their faces are so thickly piled with boulders that the rock itself was not exposed.

Red Deer River.

Leaving the shore of Lake Winnipegosis, and ascending the Red Deer River, its banks are low and alluvial for the first two miles from the lake, at the end of which distance a bare stony hill rises to about twelve feet above the river. Springs of brine issue from the top of the knoll and flow down its sides, discharging in all from one to two gallons a minute. Close to the river is a sloping exposure of rather thin-bedded, light gray, Manitoban limestone breaking into very irregular fragments and holding great numbers of *Atrypa reticularis*, with *Paracyclas elliptica*, *Cyrtina Hamiltonensis* and many other fossils. The beds are dipping east at an angle of 15°, and not more than four or five feet in all are exposed.

A short distance further up the river, on the same side, is a hill consisting of eleven feet of limestone overlaid by six feet of unstratified till. The rock is gray, yellow weathering limestone of the Manitoban series, and dips N. 60° E. at an angle of 16°. The upper five feet is a whitish limestone breaking readily into fragments and containing a number of fossils; while below it is a thicker-bedded, but not very compact, argillaceous limestone, containing but few fossils.

Cliff of argillite and limestone.

A little further up the river, and about half a mile above the lower salt spring, a cliff of limestone rises to the height of twelve feet above the water, overlaid by about ten feet of till. The cliff is about 300 feet long, and the beds dip S. 50° W. at an angle of 5°.

The following section is here shown :—

	ft.	in.
Light blue or blue-gray clay shale or calcareous argillite, the bottom beds of which contain many specimens of *Chonetes Logani*, var. *Aurora*, while the top beds are of a slightly brownish colour.....	8	0
Thin and thick-bedded light blue-gray argillaceous limestone. These beds together with the base of the overlying shales are very fossiliferous, containing *Atrypa reticularis*, *Atrypa aspera*, *Strophodonta arcuata*, *Productella subaculeata*, *Spirifera fimbriata*, *Spirifera Richardsonii*, *Cyrtina Hamiltonensis*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Porcellia Manitobensis* *Omphalocirrus Manitobensis*, *Hyolithes alatus*, *Proetus mundulus*, *Amplexus* sp., *Cyathophyllum vermiculare*, *Cyathophyllum petraoides*, *Alveolites* like *cryptodens*, *Acinoceras Hindii*.....	6	0
Thick and somewhat obscurely bedded light gray limestone, breaking on weathered surfaces into irregular fragments. It contains some of the same fossils as the beds above and appears to represent the beds in which *Atrypa reticularis* is most abundant. At		

Red Deer River—*Con.*

its top a little brine is trickling out of the rock, and just east of the exposure is a small area in which springs of brine are flowing over the surface..... 8 0

Light gray thin and evenly bedded limestone, very compact, and resounding when struck with the hammer. It contains very few fossils. To the edge of the water..... 2 0

Three-quarters of a mile further up the river, on the south side, a low anticline striking N. 50° W. brings up six feet of the light blue-gray argillaceous limestone overlaid by a foot of light blue clay shale. A few fossils were found, the same as some of those in the above list.

Half a mile higher up the stream a low anticline brings seven feet of the light gray limestone to the surface, broken in several places by little faults. It also contains a number of fossils, the same as those already recorded from the Manitoban series on this river.

Upper Salt Springs.

This last exposure is at a prominent bend in the river and a mile and a half above it a rounded hill rises on the north bank to a height of twenty feet, on the south side of which are several small brine springs where the Indians occasionally procure a small supply of salt by boiling down the water. The hill consists, to within four feet of the water at all events, of light gray limestone, the sloping face of which breaks off in irregular fragments. This locality was visited by Prof. Macoun* in 1881 and some fossils were collected from it, among which *Orthis striatula* (*O. Iowensis*) is especially noticeable as not having been obtained by the writer.

Fossils are, however, very abundant, and are generally very well weathered out by the action of the salt water. The following species were collected, and may be considered with the preceding list as a typical series for this northern portion of the Manitoban formation: *Cyathophyllum vermiculare*, var. *præcursor*, *C. Waskasense*, *C. petraoides*, *Alveolites* like *cryptodens*, *A. vallorum*? *Strophodonta arcuata*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *A. aspera*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Loxonema altivolvis*, *Proetus mundulus*.

Pelican Rapids.

For the rest of the distance to Red Deer Lake the banks are generally composed of till or alluvium, but at the head of Pelican rapids a band of light gray limestone of the Manitoban series crosses the river. Where seen it was dipping southward at an angle of 12° and contained a few fossils, such as *Atrypa reticularis*, *Omphalocirrus Manitobensis*, *Proetus mundulus*, &c.

Red Deer Lake.

Red Deer Lake lies in a very shallow basin and its shores are generally low and alluvial or composed of sand and boulders. In one place on

*Ann. Rep. Dept. of Interior, 1881, pt. 1, p. 75.

J. B. Tyrrell, Photo., Aug. 22, 1889.

CLIFF OF UPPER DEVONIAN LIMESTONE.

Rose Island, Swan Lake, Manitoba. Lat. N. 52° 36', Long. W. 100° 46'.

the south shore, however, peeping out from under the boulders, and at an elevation of from two to three feet above the water, is an exposure, showing in all a foot of a light gray, white weathering, thin-bedded limestone, dipping east at an angle of 5°, and at a hundred yards farther east there is exposed for fifty paces along the shore a horizontally bedded, light gray, slightly magnesian limestone, often red from the presence of iron. In places it is evenly bedded, while in other places it is a breccia with very irregular pebbles.

In the entire absence of fossils it is impossible to determine the exact position of these beds, but it is reasonable to infer that they form part of the upper brecciated portion of the Manitoban series, which is well shown on several of the islands in Swan Lake.

Shoal River. Returning to Lake Winnipegosis, and ascending Shoal River to the north end of Swan Lake, no rock is seen in place on or near the banks of the stream. Occasional areas are rendered wet and barren by flows of brine from salt springs, indicating the probable occurrence of the basal shales of the Manitoban series, under the covering of drift.

Swan Lake. The shores of Swan Lake are also low, and the points are often piled high with travelled boulders. But many of the islands consist of low bosses of limestone standing a few feet above the level of the water.

Rose Island. Rose Island lies towards the northern end of the lake, and consists almost entirely of beautifully glaciated limestone which at the western end rises to a height of ten feet above the water, showing at the same place a dip of 8° to the south. The rock is the fine-grained compact limestone of the upper portion of the Manitoban series, and contains a few *Athyris vittata* and other characteristic fossils. In places it is brecciated, with a matrix of more or less soft argillite, but it is not improbable that the broken character is due to the occurrence of fissures or slight faults.

The three adjoining islands were also found to consist of the same limestone under precisely similar conditions.

Swan River delta. Most of the remaining shores and islands of the lake are low, or covered with boulders, but on the eastern side of the delta of Swan River there are two rocky prominences. The northern one, N. lat. 52° 27′ 45″, long. 100° 42′ W. consists of a low exposure two feet above the water (August 31st, 1889), of a light gray stratified slightly argillaceous limestone belonging to the lower portion of the Manitoban series. On the shore were also lying many large slabs of somewhat similar limestone which had been shoved up by the ice from a thicker-bedded layer below the surface of the water. The rock con-

tains many large and well-preserved specimens of *Atrypa reticularis*, with some large *A. aspera*, besides *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Gyroceras submamillatum* and *Proetus* sp. The beds here have a light dip of 1°–2° S. 60° E.

Rock cliff.

Two miles further south, the other rocky point consists of a little cliff eight feet in height. The rock is a thick-bedded gray limestone, breaking readily into small polygonal fragments, and is generally very similar to that composing Rose Island. It appears to be raised in a low anticline, striking south-east and north-west. At the north-eastern end of a small island off this point there is a low exposure of similar limestone, but in neither places were fossils characteristic of any particular horizon to be found.

A mile north-westward from the last point, and at the eastern end of a small lake, is a stony area in which are several little springs of brine, one of which is flowing about two gallons a minute and all the rest are together flowing about twice as much. The exact horizon in the Devonian from which the brine flows was undeterminable. For many years a local supply of salt has been obtained by the half-breeds from those brine springs, and their rusted iron evaporating-pans can be seen lying here and there on the ground.

Lowest trail crossing.

Two miles and a half west of the rocky cliff on the point, is the lowest trail-crossing of the Swan River, on the south side of which is a hill rising to a height of thirty feet above the river. On the north side of this hill is a cliff six feet high showing at the bottom three feet of a horizontally, thinly and evenly-bedded light reddish limestone which appears to be unfossiliferous, while above it is a band five feet thick of a cream-coloured limestone, often saccharine and porous, with many crystals of calcite. This upper band contains a few fossils, such as *Cyrtina Hamiltonensis*, *Raphistoma Tyrrellii*, &c., and the whole probably represents a horizon in the Manitoban series just below the base of the Point Wilkins beds.

No Palæozoic rocks in place were found higher up the Swan River than in this hill at the crossing.

LAKE MANITOBA.

Low shores.

The shores south of Manitoba House were not closely examined, but they are generally low, with a ridge of sand and gravel running along at, or a little back from, the edge of the water. The water is shallow, and the gently declining lake bottom is studded with large gneissoid boulders, which are especially abundant off the more prominent points. No cliffs of the older rocks are apparent along the western shore of this portion of the lake.

North of Manitoba House the shore maintains much the same character, but boulders are stacked up somewhat more thickly on the points. On one of these points, a little north of the entrance to Ebb and Flow Lake, a boulder of Huronian conglomerate with pebbles of gneiss in a fine green matrix was lying in a pile of boulders of gneiss.

On both sides of this point extend ridges of rather angular pebbles of limestone.

Sifton Narrows.

On the east side of the lake, at Sifton Narrows, where the old location of the Canadian Pacific Railway can be plainly seen as a wide and well-cut-out line through the surrounding poplar forest, is a low exposure of porous Devonian limestone close to the edge of the water.

Old quarry.

Following the projected railway line eastward from the lake, a clearing is reached in the woods where a small quarry has been opened. The rock is a cream-coloured, harsh, semi-crystalline, porous, and very light dolomitic limestone, in which large open vesicles are rarely present. It effervesces feebly in weak hydrochloric acid, but dissolves readily in the acid when warmed, with a slight white residue. The bedding is thick and practically horizontal. 290 paces further eastward along the old line more extensive quarrying operations have been carried on. The rock is a magnesian limestone similar to the last, but here it is dipping westward at an angle of 19°, and is cut by two sets of more or less irregular jointage planes that dip at angles of 80° to the bedding. The directions of these two sets of planes are north and south, and N. 80° W. and S. 80° E. The rock weathers very rapidly, softening on exposure to the air.

Fossils.

It is a very poor medium for the preservation of fossils, but numerous fragments occur in this and the previous exposures, among which are large and small stems of Crinoids, *Cyathophyllum Anna*, *Cyathophyllum profundum*, *Pachypora cervicornis*, and *Atrypa reticularis*.

In the last-mentioned quarry about ten feet in all of the limestone is exposed, while the other two exposures represent the same or slightly higher beds near the summit of the Winnipegosan formation.

Manitoba Island.

A mile and a half north of the crossing of the old Canadian Pacific Railway, at the north end of Manitoba Island, is a cliff 200 paces in length and twelve feet high, composed of horizontal strata of hard, compact, brittle, thin-bedded limestone, very irregularly jointed and fractured. The general colour is cream, but in some places this runs into a bright buff or dull pink. A rather softer buff-coloured band runs along the face of the cliff five feet down from the top. Some of the more compact layers contain little masses and vugs of crystalline calcite, and occasional little pits are seen from which crystals of pyrite have weathered out.

Manitoba Island *Con.*

The rock breaks into very irregular flattened fragments. From the foot of the cliff a beach fifty feet wide of these flattened pebbles, which ring like a bell when struck with a hammer, with occasional boulders of gneiss, extends to the edge of the water. When the wind blows from the north and the waves roll on this shingle beach, carrying with them, both advancing and retiring, these resonant pebbles and dashing them against one another, a roaring noise is made which Indian superstition has attributed to the Manito beating a drum, or otherwise similarly disporting himself. Thus this part of the lake was called "Manito-bà," or the "Narrows of the Spirit," a name that was afterwards applied to the whole lake and then to the province in which the lake is situated.

The rock effervesces strongly in weak hydrochloric acid and dissolves quickly, leaving a flocculent pink residue of argillaceous material.

The beach at the foot of the cliff extends westward into a spit of coarse gravel, and in the pebbles that had evidently been derived from the cliff, a number of fossils were found, among which are the following: *Chonetes Manitobensis*, *Productella subaculeata*, *Atrypa reticularis*, *A. aspera*, *Nucula lirata*, *Nuculites* sp., *Paracyclas elliptica*, *Bellerophon* sp., *Orthoceras* sp., a tooth of a species of *Rhynchodus*, and a scale of a species of *Onychodus*.

Fossils.

On the east and west sides of the island low exposures of limestone are also seen, apparently horizontal, but it is generally a little softer and more yellowish-brown and argillaceous than at the cliff, and is probably a few feet lower.

Limestone on west side of strait.

On the opposite side of the strait, bearing south from the north-west end of Manitoba Island, is an outcrop 150 paces in length along the shore, of similar brittle salmon-coloured limestone. It is lying in well-defined beds of from two to six inches in thickness, and besides being broken by numerous small cracks, is cut by several series of jointage planes sloping at considerable angles from the vertical, and cracks and holes in the rock are filled with crystals and crystalline veins of calcite. The bedding appears on the whole to be about horizontal, though at the eastern end of the exposure the rocks rise in a light anticline striking N. 45° E., and dipping away on both sides at angles up to 2°. A little further west the beds all dip in towards a centre at the edge of the bushes. Nothing but obscure fragments of fossils could be found.

Base of Manitoban formation.

This limestone occupies a position at the base of the Manitoban formation, representing the southern continuation of the shales seen at South Manitou Island, and near the mouth of Bell River.

The exposed surface along the shore is smooth but lightly undulating, being modified by water erosion; and at several places back from the shore, when it was stripped of its covering of clay, it was found to present the same character. The covering, however, generally consisted of broken fragments of the rock itself, probably shoved over it by the ice.

Proceeding northward along the east side of the lake, the next exposure of Devonian rock is seen at a point on the west side of Point Richard, where a cliff rises abruptly out of moderately deep water to a height of ten feet, having been brought up by a low anticline striking N. 15° W. and S. 15° E. It is difficult to measure exactly the thickness of beds here exposed, as the bedding is heavy and indistinct, and it is only possible to examine it thoroughly from a boat in calm water, while during the day on which it was visited by the writer, a strong north wind was blowing, causing a heavy sea to beat against the face of the cliff. The section as measured, however, shows thirty feet of cream-coloured, hard, dolomitic limestone, like that seen further north at Monroe Point, full of small cavities left by the decay of numerous minute fossils, and weathering with a very irregular knobby surface. Five feet from the bottom of the section a few fossils were collected, consisting of small Crinoid stems, *Loxonema cingulatum*, and several other small gasteropods. The exposure represents a horizon about the summit of the Winnipegosan formation. Point Richard

Off Point Richard lie two small islands consisting in the centre of boulders of gneiss and cream-coloured limestone, around which is a beach of gravel.

South of these islands is a deep bay with low shores fringed by a shelving beach of glistening shingle.

Reed Island was not examined, but it appeared to be low, without rock exposures, and surrounded by a beach of gravel or boulders. Reed Island.

The shore directly east of Point Richard is low, and broken only by prominent points surrounded by sloping walls of large gneissoid boulders, piled about six feet in height, between which are circling bays cut off from the low land behind by gravel beaches, or running back into deep marshes.

The shore all the way northward to Elm Point maintains precisely the same character.

Elm Point itself is, however, a spit of limestone gravel without boulders projecting southward into deep water, formed by the action of the shore current moving southward and carrying with it and assorting the pebbles derived from the wear of the shore to the north. Elm Point.

For a short distance north of Elm Point the shore is somewhat more regular than before, with fewer boulders collected on the points. In one place the land behind the beach is a few feet higher than the lake, but boulders are shoved up against it so thickly that no section can be seen. The land, however, in all probability here consists of till, and the action of the waves has carried away the finer material, while the shoving of the ice in spring has constantly tended to pile the boulders in a compact wall along the beach.

Steep Rock Point.

Three miles and a half north of Elm Point Devonian limestone of the Manitoban series begins to make its appearance on the shore, and thence northward for two miles there is an almost continuous exposure of these rocks rising in a low anticline to a greatest height of twenty feet nine inches above the level of the water of July, 1888, while close to the foot of the highest part of the cliff the water is seventeen feet deep, giving the cliff a total height of more than thirty-seven feet.

Undermined cliffs.

The rock is white or light gray limestone, moderately thin-bedded and breaking very irregularly into angular fragments. About twenty-five feet in all are exposed and of these the lower beds are the most friable and easily worn away by the water, forming an irregular overhanging cliff, through narrow parts of which the waves have in several instances cut wide apertures, while in other places, planes of jointage have carried back the erosive agents to wear out narrow bays and caverns, the floors of which are formed of rounded limestone pebbles broken from the cliff itself.

The strata, which are just above the basal argillites or argillaceous limestones of the Manitoban formation, are not at all rich in fossils, but nevertheless the following species have been collected, viz.:—*Favosites Gothlandica*, Crinoid stems, *Monotrypa* sp., *Atrypa reticularis*, *Atrypa aspera*, *Pentamerus comis*, *Gyroceras submamillatum*, *Bellerophon Pelops*, *Euomphalus Manitobensis* and remains of fishes.

Glacial striæ.

The surface of the rock in a number of places shows well-marked glacial grooves and striæ bearing S. 13° E., and in one place, at the north-west extremity of the point, the striæ are bearing S. 2° W., while at another place on the north-east side of the point they are bearing S. 1°—8° E. At this latter place they are on a sloping beach close to the edge of the water.

The surface of the limestone is generally covered with two or more feet of clay, filled with angular fragments of the rock itself derived from close at hand, and this is often overlaid by rounded limestone gravel, while along the shore on the side of the point, boulders of gneiss are thickly scattered.

From Steep Rock Point to the head of Fairford River the shore is low and consists of a gravel ridge, on the edge of a marsh that stretches back into the interior.

Rock at head of Fairford River.

At the discharge of Lake Manitoba into the Fairford River, a band of white limestone, probably of Silurian age, crops out on the south bank close to the edge of the water, and extends northward beneath the bed of the stream. It is a white, hard, thin-bedded, and semi-crystalline limestone, and eighteen inches in all is exposed. No fossils could be found. Its surface is polished and striated, the striæ running S. 13° E.

Glacial striæ.

A mile to the east of this is a ridge six feet in height running S. 13° E., and apparently composed of the same rock, while in the vicinity of the Fairford Mission Church, and for a mile or more to the east of it, similar rock immediately underlies the surface, and occasionally rises into view in little bare knolls.

Vertical cave.

A mile and a half a little north of east from the Mission and just south of a road to Lake St. Martin, the rock comes to the surface and in it is a hole, five feet in diameter, running straight down for fourteen feet, and expanding somewhat at the bottom. I was told that the Indians of the vicinity ascribe the formation of this hole to a great snake that lived in former times. Even now they refuse to go down into it. It gives a section from top to bottom of hard compact white limestone, in places rather thin-bedded.

The cave has been formed by water charged with carbonic acid trickling through fissures in the limestone and dissolving out its more soluble portions. When examined in July, 1888, the bottom was covered with ice.

Silurian.

No fossils were found anywhere throughout this band of limestone, but it would seem evident that it is a continuation of the Silurian magnesian limestone that occupies the east side of Lake Winnipegosis, north of Birch Island.

Davis Point.

North-west of the head of Fairford River the shore of the lake is generally low, and it is not till the vicinity of Davis Point is reached that the Silurian again makes its appearance. At the southern end of this low exposure, a thin and even-bedded dolomitic limestone crops out of the bank near the water's edge, and many slabs of the same rock are scattered over the shore. No fossils were found in it, but it is doubtless the same band as is exposed at Fairford.

At the north end of the exposure, and apparently overlying the last-mentioned rock, is a layer of very thick-bedded limestone, also slightly dolomitic. It is yellow, hard and tough, but not compact like the

last, being largely composed of the debris of Stromatoporoids and corals. It weathers white, with a very rough surface.

The following fossils were collected from this latter bed: *Clathrodictyon ostiolatum*, *Clathrodictyon vesiculosum*, *Pycnostylus Guelphensis*, *Zaphrentis*, sp., and *Favosites Gothlandica*.

The north shore of Portage Bay is low, without rock exposures, with long points of boulders running out in the direction of general glacial striation. The islands off the shore are also chiefly composed of gneissoid boulders, and from the highest points there are low ridges extending S. 8° E. in the same direction as the points.

Paonan Point.

The shores of Paonan Point, as far as they were examined, were also found to present in most places a boulder wall to the lake while in the interior the land was low and marshy. Cherry Island, off the southern extremity of this point, is also surrounded by boulders on its southern side, while its northern side is a beach of gravel and sand.

North shore of lake.

West of the portage at the north end of Paonan peninsula, to the mouth of Waterhen River, no rock is seen anywhere on the north side of the lake, but the shore is everywhere low and the points and islands are surrounded by boulders, often piled up to a height of six to eight feet. Off the points, boulder reefs frequently extend into the lake for a considerable distance, while the deep bays lying between the points run back to extensive marshes. The boulders are chiefly of gneiss, mica schists and other Archæan rocks, while the pebbles on other parts of the shore are mostly of white limestone. Some of these hold impressions of salt crystals, and doubtless have been transported by the glacier from the Silurian limestone to the north.

Returning to Sifton Narrows, and thence proceeding northward up the west side of Lake Manitoba, the country is found to be very similar to that on the east side of the lake. The shore, however, is not so thickly strewn with boulders, which are generally confined to the more prominent points and to little rocky islands, while the beach in most places is composed of a ridge of finer or coarser limestone gravel extending along the face of a marsh which stretches back to a poplar forest. No rock in place is seen till Big Sandy Point is reached, one of the best known harbours on the lake. It is a spit of small pebbles of limestone and gneiss rising six feet above the water, which is six to eight feet deep close to the shore.

Big Sandy Point.

North of the harbour is a rocky hill, the face of which forms a cliff ten feet high overlooking the lake. It is composed of a harsh semi-crystalline very light brown magnesian limestone, which weathers to a somewhat darker shade of brown. It is rather thick-bedded and approximately horizontal, though the beds appear to have an undulat-

ing dip. Fossils were poorly preserved, but the following were recognized :—*Pachypora cervicornis*, Crinoidal columns, *Atrypa reticularis*, *A. aspera*, and *Pentamerus comis*.

Munroe Point.

The shore onwards past Crane River narrows is piled high with boulders, and the next Devonian exposure seen was at Monroe Point, on the west side of the mouth of Crane River. There are here three minor points, at which are little cliffs, showing respectively nine, nine, and six feet of a tough white compact or vesicular and entirely uncrystalline dolomitic limestone. In some of the compact bands, where no vesicles are present, a smooth, newly fractured or polished surface of the rock shows a kind of oolitic structure, the round or irregularly shaped oolitic grains being more opaque than the surrounding matrix. The bedding is heavy and horizontal, but at the south-easterly point there are several series of jointage planes, along which there would seem to be slight faults, with throws of a foot or two.

A large number of fossils were collected here, of which the following were broken out of the face of the cliff itself :—*Pachypora cervicornis*, *Favosites Gothlandica*, Crinoidal columns, *Cystodictya Hamiltonensis*, *Polypora Manitobensis*, *Atrypa reticularis*, *A. aspera*, *Strophalosia productoides*, *Spirifera fimbriata*, *Conocardium Ohioense*, *Euomphalus annulatus*, *Loxonema priscum*, *Loxonema cingulatum*, *Bellerophon Pelops*, *Orthoceras* sp., *Bronteus Manitobensis*.

The following species were collected from the rock debris at the bottom of the cliff, and apparently have been derived from it :—*Sphærospongia tessellata*, *Pentamerus comis*, *Terebratula Sullivanti Dentalium antiquum?*, *Naticopsis Manitobensis*, with several other small species of gasteropods.

The surface of the rock on the top of the cliff was in one place found to be smooth and glaciated, but the striæ had been entirely weathered out.

Pentamerus Point.

Three miles and a half north of Monroe Point, Pentamerus Point projects into the lake and is strewn with large irregular masses of dolomite. Off the point, a foot below the surface of the water, the bottom is found to be composed of bed rock, and the masses lying on the point have been broken from this ledge by the action of the frost and shoved up on the shore by the ice. The rock is a hard, white, vesicular dolomite, similar to that seen outcropping at Monroe Point, and, like it, containing a large number of fossils, of which the following are the most typical :—*Sphærospongia tessellata*, *Actinostroma fenestratum*, *Calumnaria disjuncta*, *Favosites Gothlandica*, *Pachypora cervicornis*, a Polyzoon, Crinoidal columns, *Atrypa reticularis*, *A. reticu-*

laris, var. *aspera*, *Spirifera fimbriata*, *Pentamerus comis*, *Rhynchonella pugnus*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*, *Myalina inflata*, *Spathella subelliptica*, *Glossites Manitobensis*, *Dentalium antiquum*, *Pleurotomaria infranodosa*, *Pleurotomaria* (sp. reversed), *Porcellia Manitobensis*, *Eunema clathratulum*, *Astralites fimbriatus*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Platyostoma tumidum*, *Naticopsis Manitobensis*, *Loxonema priscum*, *Pleurotomaria Spenceri*, *Gyroceras filitextum*, *Orthoceras Tyrrellii*, and *Bronteus Manitobensis*.

Horizon. These two localities are quite typical of the Winnipegosan formation.

Five miles a little west of north from Pentamerus Point, a prominent point stretches out into the lake to the west of the harbour of Little Sandy Point, and is underlaid by a rather thin-bedded bluish-gray limestone, rising with a gentle slope out of the water. Its surface is

Glacial striæ. well glaciated, showing grooves bearing S. 12° W., crossed by fine striæ bearing S. 8° E. The rock holds a few fossils, the same as those just to be recorded from Onion Point.

A slight exposure of similar limestone forms a little cliff at Flat

Onion Point. Rock Point, but the main exposure is at Onion Point, a mile and a half still further west. Here a vertical cliff, eight feet high, faces the lake, and extends 150 yards along the shore. It is composed of white or light gray limestone, very evenly bedded, and the beds appear on the face of the cliff to be from two to three feet in thickness, but they readily break into thinner layers, and have also an irregular cross-fracture which would make it difficult to quarry pieces of any considerable or regular size.

Anticline. The rock is brought up by a low anticline striking N.W., and towards the north-east it dips at an angle of 2° to the edge of, and beneath the water, while to the south-west it breaks off abruptly above a tail heap of large boulders. The total thickness of rock seen is nine feet six inches.

Fossils Fossils were very plentiful, but, unlike those at Monroe and Pentamerus points, they belong to comparatively few species. *Atrypa reticularis*, *A. reticularis*, var. *aspera* and small Crinoidal columns are particularly abundant, while *Paracyclas elliptica*, *Euomphalus Manitobensis* and *Raphistoma Tyrrellii*, are found in considerable numbers. With them the following species also occur:—*Pachypora cervicornis*, *Cyathophyllum petraioides*, *Cyrtina Hamiltonensis*, *Productella subaculeata*, *Kefersteinia subovata?*, *Bellerophon Pelops*, *Loxonema altivolvis*, *Euomphalus circularis*, var. *subtrigonalis*, *Orthoceras Hindii*, and *Hyolithes alatus*.

This locality is typical of a zone near the base of the Manitoban formation.

SYSTEMATIC GEOLOGY.

TABLE OF FORMATIONS.

	Feet.
RECENT.	
Present lake beaches. Delta deposits in Dauphin, Swan and Red Deer Lakes, &c.	
POST TERTIARY.	
Champlain.	
Terraces in the valleys of Shell and Assiniboine rivers and their tributaries. Beaches and deltas of Lake Agassiz on the slope of the Manitoba escarpment, at least as far northward as Red Deer River.	
Glacial.	
Till on the general surface. Moraines on and in front of the Riding, Duck and Porcupine mountains; north of Lake Winnipegosis, &c. Drumlins in the lakes, and in the Assiniboine valley. Kames in the Valley river valley, &c.	
Inter or *Preglacial.*	
Clays and sands on Rolling River and at Churchbridge.	
CRETACEOUS.	
Pierre.	
Odanah Series.	
Light gray hard fissile shales very poor in fossils, occurring on the upper portion of Riding Mountain and southward to the International Boundary line.	400
Millwood Series.	
Dark gray soft shale.	664
Niobrara.	
Light gray mottled calcareous clay shale with bands of chalky limestone, everywhere containing a large number of foraminifera.	130–540
Benton.	
Dark gray very soft non-calcareous clay shale, poor in fossils, and weathering into gentle slopes.	160
Dakota.	
A rather soft white or light gray sandstone often calcareous.	13–200
DEVONIAN.	
Upper Devonian or *Manitoban.*	
Light gray hard brittle limestone containing *Athyris vittata*, &c., underlaid by red argillites, outcropping at Rose Island nd vicinity in Swan Lake, and at Point Wilkins.	100
Light gray hard limestone seen at Onion Point, Snake Island, Beardy Island, &c.	40
Red and gray shale seen near the mouth of Bell River, south of Weston Point, &c.	70

Middle Devonian or *Winnipegosan.*

	Feet.
Whitish or light yellow, hard, tough, generally compact, dolomite containing *Stringocephalus Burtini* and numerous other fossils. It outcrops chiefly on the islands and shores of Dawson Bay, and southward to Point Richard on Lake Manitoba.	100
Porous spongy yellow dolomites of Pemmican Island, Devil's Point, Macoun Point, &c.	100

Lower Devonian.

These beds have not been clearly defined, but they appear to be composed of red and other shales.	100

SILURIAN.

Niagara.

Compact, thin bedded dolomites, found chiefly on the west side of Lake Winnipegosis.	
Compact and porous dolomites containing a considerable number of fossils, seen on Cross Lake and vicinity.	
Hard, tough, light yellowish dolomitic limestone, seen on the Saskatchewan River at Grand rapids.	
Soft white or light yellow chalky or argillaceus limestone, with a number of fossils. Near the bottom is a hard band containing large numbers of *Pentamerus decussatus.*	200

SILURIAN.

Area.

The Silurian occupies the whole of the north-eastern portion of the area described in the present report, where it is represented by a series, a few hundred feet in thickness, of light gray limestones and dolomites.

Lower Niagara limestone.

The lower portion of the system is best shown in the gorge at the Grand Rapids, near the mouth of the Saskatchewan River, where it outcrops in a horizontal attitude a few miles south of an exposure of Trenton limestone on the west side of Lake Winnipeg.

The following descending section is here shown :—

	ft.
1. White thin-bedded limestone	15
2. Covered	6
3. Soft yellow limestone	8
4. Gap in section	10?
5. Hard yellow magnesian limestone	4
6. Moderately thin-bedded white limestone	8
7. Hard compact buff limestone	1
8. Brecciated limestone	2
	54

The three lower bands are, as far as is at present known, quite unfossiliferous, while No. 5 contains a great number of a beautifully preserved *Pentamerus*, recently described by Mr. Whiteaves as *P. decussatus.* With it are found *Favosites Niagarensis, Alveolites* sp., *Lyellia* sp., *Halysites catenulatus, Orthis* sp., and *Euomphalus* sp.

Above No. 5 is a gap in the section where the beds have been worn away, being in all probability too soft to resist erosion to the same extent as the surrounding beds.

In band No. 3 fossils were not plentiful, but *Strophomena acanthoptera* and *Leperditia Hisingeri*, var. *fabulina* were collected. This band is generally porous and contains a large number of impressions of salt crystals. In places the bedding is moderately even and horizontal, but generally it is hardly discernible, and the rock breaks into very irregular lumpy pieces. Lying on the bank, and having been apparently derived from this band, are some nodules of marcasite, and red masses of ironstone.

No. 1 is a thin-bedded, white, horizontal, chalky limestone, in places argillaceous, very light, and breaking regularly when struck with the hammer. It has a more or less granular structure, and in places was strongly ripple-marked. A thin band a few feet below the top, contains a considerable number of fossils, among which are the following: *Favosites Niagarensis*, *Leptocœlia* sp., *Rhynchonella* sp., *Pterinea aviculoidea?*, *Pleurotomaria occidens*, *Orthoceras* sp., *Gomphoceras parvulum*, *Leperditia Hisingeri*, var. *egena*, *Leperditia cœca*, and *Isochilina grandis*, var. *latimarginata*.

This series is sharply delimited above, and probably also below, though its exact contact with lower beds has not been observed. It appears to occupy a position at the base of the Silurian (as distinguished from the Cambro-Silurian) system and probably represents the lower part of the Niagara of Wisconsin, &c.

Upper Niagara limestone.

Overlying the lower Niagara limestones is a considerable thickness, possibly a few hundred feet, of dolomites and dolomitic limestones of Upper Niagara age.

Grand Rapids

The base of this series is well shown in the gorge of the Grand Rapids, where it consists of ten feet of a hard, tough, light-yellowish dolomitic limestone, rather indistinctly bedded, but conformable to the underlying series. It is generally clearly fragmental, and in its lower portion contains a large number of salt crystals. Fossils are here moderately plentiful, but difficult to break out. Crinoid stems are very abundant, and with them are *Favosites Gothlandica*, *Zaphrentis* sp., and *Strophomena acanthoptera*.

This crinoid bed grades up into, and is overlaid by, from twenty to thirty feet of hard, brittle, yellow dolomite, generally thinly and evenly bedded. The only fossil here appears to be a large Stromatoporoid.

This compact band is overlaid by a porous yellow dolomite in moderately thin but uneven beds, and contains many impressions of salt crystals.

Cedar and Winnipegosis Lakes.

From Grand Rapids, where the above section was obtained, beds of this series have been traced westward through Cross Lake to the extreme west end of Cedar Lake, and down the east shore of Lake Winnipegosis from its north-east angle to latitude 52° 32′, as well as on the Fairford River and at several points around Lake St. Martin. Throughout this distance all the exposures are low and practically horizontal, and though there is considerable local variation in the character of the rock, it is doubtful whether the variations are sufficiently persistent to enable the geologist to determine with any degree of accuracy the total thickness of the terrane. In many places the beds are hard and almost slate-like, but these merge both vertically and horizontally into others that are much more porous and often contain many impressions of salt crystals. At the north-east angle of Lake Winnipegosis one bed is thick and almost porcellanous in texture, and close by is another heavy bed containing many large and small nodules of gray chert. In the immediate vicinity is a thin-bedded slaty dolomite very much broken by minute fissures, and having its surface often thickly strewn with fossil ostracods. Farther north, at Cross Lake Rapids, similar ostracodous dolomites are associated with more porous and highly fossiliferous beds, corresponding closely with the Niagara limestone of Wisconsin.

Niagara fossils.

The following is a rough provisional list of the fossils found in this formation :—

Stromatopora sp.
Calapœcia sp.
Zaphrentis Racinensis? Whitfield.
Cyathaxonia Wisconsinensis? Whitfield.
Omphyma sp.
Favosites Gothlandica, Lamarck.
Favosites Niagarensis, Hall.
Alveolites Niagarensis, Rominger.
Halysites catenulatus, L.
Lyellia papillata? Rominger.
Orthis sp.
Strophomena acanthoptera, Whiteaves. N. sp.*
Rhynchonella sp.
Rhynchonella altiplicata? Hall.
Atrypa reticularis, L., (young).
Leptocœlia sp.
Meristella sp.
Pentamerus decussatus, Whiteaves. N. sp.
Trematospira formosa, Hall.
Pterinea aviculoidea? Hall.

* N. sp. is inserted in these lists after species described in the reports cited on pages 19 and 20 from collections made in the course of the present exploration.

Murchisonia sp.
Pleurotomaria occidens, Hall.
Pleurotomaria Hoyi ? Hall.
Pleurotomaria sp.
Polytropis sp.
Enomphalus sp. (very small).
Orthoceras sp.
Orthoceras sp.
Gomphoceras parvulum, Whiteaves. N. sp.
Gyroceras sp.
Dalmanites sp.
Illaenus sp.
Acidaspis perarmata, Whiteaves. N. sp.
Isochilina grandis, var. *latimarginata*, Jones. N. var.
Leperditia Hisingeri, var. *fabulina*, Jones. N. var.
" " " *egena*, Jones. N. var.
" " " *gibbera*, Jones. N. var.
" *cæca*, Jones. N. sp.
" *phaseolus*, Hisinger.
" *Whiteavesii*, Jones. N. sp.
" *marginata*, Schmidt.

Southern extension of the terrane.

In the vicinity of Lake St. Martin thin-bedded dolomites of this formation rest directly on and against rounded bosses of red micaceous granite, and green soda-rich syenite porphyry, which have formed elevated portions of the Archæan floor on which the Palæozoic rocks of Manitoba were deposited. Elsewhere they would appear to rest on undisturbed limestones and shales of Cambro-Silurian age.

Gypsum.

A short distance west of these isolated bosses of Archæan rocks an irregular hilly tract rises above the gently sloping wooded plain. The hills are found for the most part to be composed entirely of massive or crystalline gypsum, while a few consist of light bluish-white anhydrite.

On the eastern shore of Lake Manitoba, a short distance west of this gypsum outcrop, the thin-bedded Upper Niagara dolomites are overlain by a few feet of a thick-bedded massive stromatoporoid magnesian limestone in which the only fossils found were a few corals, but among them *Pycnostylus Guelphensis* could be easily recognized. This limestone forms the upper beds of the Niagara of this region, but it has not been deemed advisable to separate the horizon as Guelph on the evidence of a fossil whose range is so little known, especially as the Leperditia beds below it show so many points of similarity to the Lower Helderberg of Wisconsin.

South of the region of the lakes the Silurian has not yet been outlined, but some fragments of rock collected from the top beds at Stonewall look as if they might belong to this system, and the high ridge between Lakes Manitoba and Winnipeg is not improbably capped by beds of the same age.

DEVONIAN.

Position.

Overlying the Niagara dolomites in the region of Lakes Winnipegosis and Manitoba there is a considerable thickness, probably a hundred feet or more, of strata, of which no natural exposures have yet been recognized. That these strata are softer than the overlying and underlying beds, is testified to both by the absence of any cliffs of hard rock, and by the presence of an extended depression along the strike of the beds, now largely occupied by the above-mentioned lakes. A bed of red clay or shale, just above this gap, is seen on Pemmican Island, &c., and it is not improbable, considering the argillaceous character of many of the overlying limestones, that the whole of the concealed series is composed of argillaceous shales or soft limestones. The absence of sand from the till of that region makes it unlikely that much sandstone is included in the series.

Lower Devonian.

These shales are placed at the local base of the Devonian system, since the above-mentioned red bed lies conformably below Devonian dolomites, and there is little or no evidence at hand to prove the presence or absence of an unconformity at the top of the Silurian. These shales may, therefore, possibly represent the Corniferous in Manitoba, and the Palæozoic strata passed through in the Morden well probably represent the more southern continuation of this formation.

Winnipegosan formation.

The next rock in ascending order is a series of light brown or gray, harsh, porous, and very irregularly weathering, dolomitic limestones, having a probable thickness of a hundred feet or more. This zone or terrane contains a number of typical Devonian fossils, among which the following are some of the most characteristic, viz.: *Atrypa reticularis*, *Pentamerus comis*, *Productella subaculeata*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Bellerophon Pelops*, *Straparollina obtusa*, &c. Nearly all these fossils are also characteristic of the immediately overlying zone.

Hard dolomites.

Stringocephalus zone.

The harsh dolomites are overlaid by a somewhat similar thickness of very thick-bedded white tough dolomites, often containing more porous bands, in which are many well-preserved casts of salt crystals. These compact dolomites have yielded a rich harvest of fossils, among which are many forms, such as *Stringocephalus Burtini*, *Pentamerus*

comis, &c., typical of the Middle Devonian of Europe. The harsh, and the compact dolomites are therefore regarded as the lower and upper portions of the Winnipegosan formation or Middle Devonian. They are best exposed on the islands and shores of Dawson Bay, near the north-west extremity of Lake Winnipegosis, and isolated outcrops are seen on the shores as far south as "Sifton's Narrows," on Lake Manitoba. South of this point no natural exposures of Devonian rocks have yet been recognized in the province of Manitoba.

Manitoban formation.

Above the Winnipegosan dolomites the base of the Manitoban formation or Upper Devonian consists of red and gray calcareous shales, from forty to seventy feet in thickness, containing comparatively few fossils. These shales are, however, almost everywhere marked along their eastern outcrop by brine springs that pour a copious flow of salt water over the surface of the underlying dolomites.

Above the shales is a comparatively thin band of argillaceous and highly fossiliferous light gray limestone, in which *Atrypa reticularis* and *Paracyclas elliptica* are especially abundant.

The highest Palæozoic rocks seen in Manitoba, but possibly still low down in the Upper Devonian, outcrop on some islands in Swan Lake, and in the high promontory of Point Wilkins, on the west side of Dawson Bay. They consist of from sixty to eighty feet of light gray compact brittle limestone not very rich in fossils, but those that are present, viz.: *Atrypa reticularis*, *Cyrtina Hamiltonensis*, *Athyris vittata*, *Paracyclas elliptica*, *Bellerophon Pelops*, &c., are typically Devonian.

Devonian fossils.

The following is a list of the fossils from the Devonian rocks of Manitoba and vicinity, all of which, except *Orthis striatula*, were collected on the recent explorations under the charge of the writer. The letters M. and U. indicate that they were found in either the Middle or Upper Devonian, respectively.

PROTOZOA.

Sphærospongia tessellata, Phillips.		M.
Astræospongia Hamiltonensis, Meek & Worthen.		M.

CŒLENTERATA.

Cyathophyllum vermiculare, var. *præcursor*, Frech.		U.
" *dianthus*, Goldfuss.		U.
" *Waskasense*, Whiteaves.	N. sp.	U.
" *petraioides* "	N. sp.	U.
" *Anna*, Whitfield.		M.
" *profundum*, Hall.		M.
" *profundum*, Hall, var.		U.
" *Athabascense*, var.		U.

Columnaria disjuncta, Whiteaves. N. sp.	M.
Amplexus sp.	M.
Actinocystis variabilis, Whiteaves. N. sp.	M.
Favosites Gothlandica, Lamarck.	M.
Pachypora cervicornis, DeBlainville.	M.
Pachypora or *Alveolites*.	U.
Alveolites vallorum, Meek.	M. U.
Clathrodictyon (like *C. laxum*, Nicholson.)	U.
Stromatopora sp. (cfr. *L. Bücheliensis*, Bargatzky.)	M.
" sp. (cfr. *L. Hüpschii*, Bargatzky.)	M. U.
Actinostroma expansum, Hall & Whitfield	M.
" *Tyrrellii*, Nicholson. N. sp.	M.
" *fenestratum*, Nicholson.	M.

ECHINODERMATA.

Ctenocrinus sp.	M.

VERMES.

Spirorbis omphalodes, Goldfuss.	M.

POLYZOA.

Leptotrypa quadrangularis, Nicholson.	U.
Pinacotrypa marginalis, Whiteaves. N. sp.	M.
Cystodictya Hamiltonensis, Uhlrich.	M.
Fenestella vera, Uhlrich.	M.
" *dispanda ?* Hall.	M.
Polypora Manitobensis, Whiteaves. N. sp.	M.
Monotrypa sp.	U.

BRACHIOPODA.

Discina sp.	M.
Chonetes Logani, var. *Aurora*, Hall.	U.
" *Manitobensis*, Whiteaves. N. sp.	U.
Strophalosia productoides, var. *membranacea*.	M.
Productella subaculeata, Murchison.	M. U.
Orthis striatula, Schlotheim.	U.
" *Manitobensis*, Whiteaves. N. sp.	M.
Orthothetes Chemungensis, Conrad.	M.
Strophodonta arcuata, Hall.	U.
" *interstrialis*, Phillips.	M.
Spirifera fimbriata, S. A. Miller.	M. U.
" *Richardsonii*, Meek.	M. U.
Cyrtina Hamiltonensis, Hall.	U.
Athyris vittata, Hall.	U.
Atrypa reticularis, L.	M. U.
" " var. *aspera*, Schlotheim.	M. U.

Rhynchonella pugnus, Martin.	M.
Pentamerus comis, Ower.	M. and base of U.
Stringocephalus Burtini, Defrance.	M.
Terebratula Sullivanti, Hall.	M.

LAMELLIBRANCHIATA.

Pterinea lobata, Whiteaves. N. sp.	M.
Actinopteria Boydii, Conrad.	M.
Gosseletia sp.	M.
Mytilarca inflata, Whiteaves. N. sp.	M.
Myalina trigonalis, " N. sp.	M.
Modiomorpha attenuata, Whiteaves. N. sp.	M.
" *compressa*, " N. sp.	M.
" *tumida*, " N. sp.	U.
" *parvula*, " N. sp.	M.
Spathella subelliptica, " N. sp.	M. U.
Goniophora perangulata, Hall.	M.
Macrodon pygmæus, Whiteaves. N. sp.	M.
Nucula lirata, Conrad.	U.
" *Manitobensis*, Whiteaves. N. sp.	M.
Nuculites sp.	U.
Kefersteinia subovata, Whiteaves. N. sp.	M. U.
Mecynodon Eifeliensis ?, Frech.	M.
Anodontopis affinis, Whiteaves. N. sp.	M.
Paracyclas antiqua, Goldfuss.	M.
" *elliptica*, Hall.	U.
" " var. *occidentalis*, Billings.	U.
" sp.	M.
Conocardium Ohioense, Meek.	M.
Cardiopsis tenuicostata, Whiteaves. N. sp.	M.
Cypricardella bellistriata, Conrad.	M. U.
" *producta*, Whiteaves. N. sp.	M.
Cypricardinia planulata, Conrad.	M.
Glossites Manitobensis, Whiteaves. N. sp.	M.
Orthonota corrugata, Whiteaves. N. sp.	M.

GASTEROPODA.

Dentalium antiquum ? Goldfuss.	M.
Palæacmæa cingulata, Whiteaves. N. sp.	M.
Pleurotomaria goniostoma, Whiteaves. N. sp.	M.
" *infranodosa*, " N. sp.	M.
Pleurotomaria Spenceri, " N. sp.	M.
Raphistoma Tyrrellii, Whiteaves. N. sp.	M. U.

Murchisonia turbinata, Schlotheim.		M.
" *Dowlingii*, Whiteaves.	N. sp.	M.
Bellerophon Pelops, Hall.		M. U.
Porcellia Manitobensis, Whiteaves.	N. sp.	M.
Eunema speciosum, Whiteaves.	N. sp.	M.
" *brevispira*, "	N. sp.	M.
" *subspinosum*, "	N. sp.	M.
" *clathratulum*, "	N. sp.	M.
Astralites fimbriatus, "	N. sp.	M.
Euomphalus annulatus, Phillips.		M.
" *subtrigonalis*, Whiteaves.	N. sp.	U.
Omphalocirrus Manitobensis, "	N. sp.	U.
Straparollina obtusa, "	N. sp.	M.
Pseudophorus tectiformis, "	N. sp.	M.
Platyceras parvulum, "	N. sp.	M.
Platyostoma tumidum, "	N. sp.	M.
Naticopsis Manitobensis, "	N. sp.	M.
" *inornata*, "	N. sp.	M.
Loxonema altivolvis, "	N. sp.	U.
" *priscum*, Munster.		M.
" *cingulatum*, Whiteaves.	N. sp.	M.
" *gracillimum*, "	N. sp.	M.
Macrochilina subcostata, Schlotheim.		M.
" *pulchella*, Whiteaves.	N. sp.	M.

PTEROPODA.

Hyolithes alatus, Whiteaves.	N. sp.	M. U.

CEPHALOPODA.

Orthoceras Hindii, Whiteaves.	N. sp.	U.
" *Tyrrellii*, "	N. sp.	M.
Gomphoceras Manitobense, Whiteaves.	N. sp.	U.
Cyrtoceras occidentale, "	N. sp.	M.
Homaloceras planatum, "	N. sp.	M.
Tetragonoceras gracile, "	N. sp.	M.
Gyroceras Canadense, "	N. sp.	M.
" *filicinctum*, "	N. sp.	M.
" *submamillatum*, "	N. sp.	U.

CRUSTACEA.

Isochilina Dawsoni, Jones.	N. sp.	M.
Elpe Tyrrellii, "	N. sp.	M.

Leperditia exigua, Jones.	M.
Bronteus Manitobensis, Whiteaves. N. sp.	M.
Lichas sp.	M.
Cyphaspis bellula, Whiteaves. N. sp.	M.
Proetus mundulus, " N. sp.	M. & U.

FISHES.

Ptyctodus calceolus, M. & W.	U.
Rhynchodus sp.	U.
Dinicthys Canadensis, Whiteaves. N. sp.	U.
Aspidicthys notabilis, " N. sp.	U.
Onychodus sp.	U.

Extension of the Devonian.

South of "Sifton Narrows" on Lake Manitoba, no Devonian rocks are known to outcrop within the Province of Manitoba. Northward and north-westward of Lake Winnipegosis the characters of the Palæozoic rocks, other than those on Cedar Lake, have not yet been determined throughout a distance of almost five hundred miles, or till the Clearwater and Athabasca Rivers are reached. Here Devonian rocks, very similar in character to the Upper Devonian of Manitoba, have again been recognized, and traced northward along the Athabasca and Mackenzie rivers to within the Arctic Circle.

CRETACEOUS.

Dakota.

Sandstone.

This formation, resting unconformably on the limestones of the Devonian, is composed of white or reddish sandstones, either cemented by a calcareous matrix or often quite incoherent, being then an even-grained white quartzose sand. It grades up into a light green and rather hard sandstone, commonly interstratified with thin bands of shale.

Fossils.

Very few fossils have been found in this sandstone, and those that have been found are confined to the greenish upper beds. They consist chiefly of carbonized fragments of wood and coniferous leaves, but the following animal remains have also been collected, viz.:—

Lingula subspatulata, Hall and Meek.
Ostrea congesta, Conrad.
Modiola tenuisculpta, Whiteaves. N. sp.
Cycloid scales of fishes.

Outcrops.

The terrane can be seen in several exposures along the foot of the northern portions of the Manitoba escarpment, as on the banks of Red Deer, Armitt, Kematch and Swan rivers, and on Kettle Hill, south of

Swan Lake. Also at Pemmican Island, in Lake Winnipegosis, there are evidences of the presence of this or the overlying terrane.

Thickness.

The exposures were altogether too small and infrequent to allow of any exact determination of its total thickness to be made, but on account of the irregularity of the Palæozoic floor on which it was laid down, this certainly varies greatly, even within short distances. Near the north-west corner of the map it has probably a maximum thickness of two hundred feet, while on the north side of the Riding Mountain, where it was passed through in the Manitoba Oil Company's well on Vermilion River, it has, so far as can be determined from the few specimens at hand, a thickness of nineteen feet.

Extension.

South of this point these sandstones have not been recognized in natural exposures within the province, but they are again reported in the states to the south. Towards the north-west they would appear to be represented by the "Tar Sands" on the Athabasca River, but the formation has not yet been determined to be continuous throughout the intervening area.

Benton.

Dark gray shales.

Overlying the Dakota sandstones, the Benton formation occurs as a band of dark gray, almost black shale, holding a considerable quantity of carbonaceous material. This shale is evenly bedded, and breaks down readily into thin flakes, on which account it generally forms sloping banks. With the dark shales are associated thin beds of white, soft, sweet-tasting magnesian clay.

In the bore on Vermilion River, the Benton appears to be 178 feet thick, and further north, on the face of the Duck and Porcupine mountains, it continues of about the same, or slightly less, thickness. It is easily recognized, even when good naked exposures are absent, by its characteristic property of breaking into more or less minute graphite-like flakes, and not weathering immediately into a soft clay, as usually occurs in the less consolidated beds of the Pi[illegible]

It is generally quite destitute of fossils, but in a few places undeterminable fragments of oysters and Inocerami have been collected from the shale.

Niobrara.

Mottled calcareous shale.

The Niobrara formation conformably overlies, and is an upward extension of, the Benton. The rock, however, instead of being a soft fissile shale, with little or no admixture of calcareous material, is a lighter gray calcareous shale or marl, sometimes varying to a band of moderately hard limestone. This is especially the case at the top of the terrane, where a band of grayish chalky limestone is generally met with. This band is often highly charged with pyrite.

A very characteristic feature of the formation is the presence of a large number of Foraminifera, among which *Globigerina cretacea* is often very conspicuous and in great abundance. From most of he exposures throughout north-western Manitoba, the species of foraminifera have not yet been authoritatively determined, but in specimens from Edwards Creek, and from a depth of 1,115 feet in the deep well at Deloraine, in southern Manitoba, the following species were kindly determined for me by Mr. C. Davies Sherborn, of London, England :— Fossils.

Globigerina cretacea, d'Orbigny.
" *bulloides*, d'Orbigny.
" *linnæana*, d'Orbigny.
Cristellaria rotulata, Lamarck.
Planorbulina ammonoides, Reuss.
Anomalina rotula, d'Orbigny.
Bulimina variabilis, d'Orbigny.
Textularia globulosa, Ehrenberg.
Verneuilina triquetra, d'Orbigny.
Marginulina variabilis, Neugeboren.
Dentalina ? auperata, d'Orbigny.

Coccoliths and *Rhabdoliths* are also found in many of the specimens. With these minute forms may also occur in great abundance the fragments of shells of a large *Inoceramus* together with the following species :—

Serpula semicoalita, Whiteaves. N. sp.
Ostrea congesta, Conrad.
Anomia obliqua, Meek & Hayden.
Inoceramus problematicus, Schlotheim.
Belemnitella Manitobensis, Whiteaves. N. sp.
Loricula Canadensis, Whiteaves. N. sp.
Ptychodus parvulus, Whiteaves. N. sp.
Lamna Manitobensis, Whiteaves. N. sp. (loose.)
Enchodus Shumardi, Leidy.
Cladocyclus occidentalis, Leidy.

Very characteristic exposures of this formation may be seen in the valleys of all the streams on the north side of Riding Mountain from the Ochre to the Valley rivers, the highest cliffs being usually in the vicinity of some of the strongest of the old shore lines of Lake Agassiz. North of Valley River no outcrops of Cretaceous rocks were detected on the east face of Duck Mountain until North Pine Creek was reached. Here the foraminiferous Niobrara marls are again well exposed, and on Swan River and its tributaries, and on the streams flowing from the eastern and northern slopes of Porcupine Exposures.

Mountain many excellent sections were discovered, so that these rocks form a clearly marked horizon in the middle of the Cretaceous of Manitoba. They generally weather into steep or vertical cliffs, and consist as a rule of gray calcareous shale, with a mottled appearance caused by the presence of large numbers of Foraminifera.

Thickness.

The terrane varies considerably in thickness. In the Manitoba Oil Company's bore on Vermilion River it appears to have a thickness of 130 feet. On North Pine Creek its total thickness is less than 400 feet, and probably is not more than 200 feet. On Bell River it is probably less than 250 feet. In the Swan River valley, near Thunder Hill, it would seem to have a thickness of 540 feet, but it is quite possible that the upper beds represent a foraminiferous horizon in the overlying Pierre formation.

Extension.

This terrane is known to extend southward through the western portion of the province of Manitoba, having been recognized in the valleys of the Assiniboine and other streams near the face of the Manitoba escarpment, and in the borings from the deep wells at Morden and Deloraine. It is doubtless continuous with the Niobrara shales and limestones, originally described by Messrs. Meek and Hayden, from the banks of the Missouri River in Nebraska. Northwest of the area now described, a fragment of typical Niobrara rock was collected from Carrot River, about west long. 103°, by Mr. A. L. Russell, beyond which it has not been traced, and its exact correlation with the beds on Athabasca River is not yet known.

Pierre.

Grading upwards from the top of the Niobrara formation the Pierre shales occupy the summits of all the higher lands of the Riding, Duck and Porcupine mountains. In the Riding Mountain and further south this formation naturally separates itself into an Upper and a Lower Subdivision, which the writer has elsewhere called the Millwood and the Odanah Series.* It is not improbable that the separation of these two series could also be traced northward through the Duck and Porcupine mountains, but that no sections exposing the Cretaceous were found in any of the higher parts of the country, or above the heights at which the Millwood Series might be expected to be found. This series is composed of dark grey soft clay shales very similar to those already described by Dr. Dawson, Mr. McConnell and the writer from Alberta and Assiniboia, containing crystals of selenite and septarian nodules of ironstone. Further west the Pierre is highly fossiliferous, but in north-western Manitoba fossils are very scarce, and of those recorded in the following

Subdivisions.

Millwood series.

*"The Cretaceous of Manitoba," by J. B. Tyrrell. Am. Jour. Sci., vol. 40, (1890) pp. 227-232.

list the Radiolaria are from a bed of shale on Bell River, and the remainder are from ironstone nodules from the west bank of the Assiniboine Valley at Millwood, a short distance south of the present map. Radiolaria and other fossils.

Caryosphæra æquidistans, Rüst. N. Sp.
Cenellipsis hexagonalis, " "
Prunulum calococcus, " "
Cyrtocalpis crassitestata, " "
Dictyocephalus microstoma, " "
" *macrostoma*, " "
Theocampe sphærocephala, " "
Tricolocapsa salva, "
" *thoracica*, " N. Sp.
" *Dowlingi*, " "
" *Selwyni*, " "
Dictyomitra Canadensis, " "
" *polypora*, Zittel.
" *multicostata*, Zittel.
Stichocapsa Tyrrelli, Rüst. N. Sp.
" *Dawsoni*, " "
Pteria linguiformis, Evans and Shumard.
Inoceramus tenuilineatus, Hall and Meek.
" *Sagensis*, var. *Nebrascensis*, Owen.
Nucula sp.
Lucina occidentalis, Morton.
Entalis paupercula, Meek & Hayden.
Dentalium gracile ? "
Baculites compressus, Say.
Scaphites nodosus, var. *quadrangularis*, Owen.
Hylobiites cretaceus, Scudder. N. Sp.
Fragments of fishes.

These shales everywhere form the banks of the Assiniboine valley from Fort Pelly southward, the river flowing on the strike of the terrane. They are also shown in high cliffs on the banks of Ochre and Vermilion rivers and Edwards Creek on the north face of Riding Mountain, the exposure on the latter stream showing the total thickness of the series. Further northward, on the eastern face of the escarpment, the Lower Pierre was recognized on North Pine and Bell rivers, in both of which places it was highly siliceous and contained large numbers of Radiolaria of the above-named species. For the rest the higher slopes are covered with drift. Outcrops.

These Millwood shales extend southward to the International Boundary, being seen at the foot of the bank at Minnedosa; in the valley of Extension.

Horse Creek west of Morden, and in many other places. Towards the north-west they have not yet been followed, but they are not improbably continuous with the similar dark shales on the Saskatchewan, and under large areas of the great plains.

Odanah series. The Millwood shales are overlaid by a considerable thickness of Upper Pierre light gray hard clay shales which are locally known as slate, and which, from their typical development at Odanah, near Minnedosa, on the Little Saskatchewan River, have been called by the w iter the *Odanah Series*. Throughout the series are many beds of septarian ironstone nodules, but very few of these are compact like those in the Millwood series, and they are generally cut by many veins of crystalline calcite. No fossils were found by the writer in these shales, but Professor H. Y. Hind, in 1858, collected some fossils from beds of this series, near the mouth of Two Creeks, in township 13, range 27, which clearly show that these shales belong to the marine Cretaceous Pierre formation.*

The following is a list of these fossils :—

Anomia Flemingi, Meek.
Inoceramus Canadensis, Meek.
Yoldia Hindi, Meek.
Lunatia obliquata, Hall and Meek.
Cinulea concinna, Hall and Meek.
Ammonites, sp undet.

Character. The cliffs of this terrane generally weather with a more or less sloping surface, but in railway cuttings, or by some streams, where erosion is very rapid, they rise almost vertically, presenting a general lead-gray appearance. The beds are also much fissured, and iron stains are everywhere seen along the lines of fissure. On a fresh surface the shale can be readily cut, but it quickly hardens on exposure to the atmosphere, and the streams cutting through it have their banks strewn with lenticular pebbles derived from it. In some places, as in the valley of the Little Saskatchewan River near Minnedosa, alluvial beds of these pebbles are being used as ballast for the railway.

Outcrops. The Odanah series is well shown in the upper part of the valley of Edwards Creek, where it conformably overlies the Millwood shales. Slight exposures are also seen on the upper parts of Vermilion River, and the bed of Ochre River is thickly strewn with pebbles derived from

*In a paper on "The Cretaceous of Manitoba" in Am. Jour. Sci., vol. 40, 1890, p. 230, the writer states that the above-named fossils are probably from the Millwood series, but since that paper was written he has carefully examined the banks of the Assiniboine near where these fossils were collected, and has also examined the fossils themselves in the Museum of the Geological Survey of Canada. He is therefore now able to say definitely that the character of the rock in which they are imbedded proves them to be from the Odanah series or Upper Pierre.

it. Pebbles of this shale are first washed into the Assiniboine valley near the mouth of Skunk Creek, and a well at Barnardo's farm near Russell is stated to have been sunk 170 feet through these shales to the underlying series.

Extension. Fifty miles down the Assiniboine valley below the southern edge of the present map, these shales become conspicuous along its sides, and for thirty-five miles, or to opposite Griswold, the banks are more or less formed of them, and barren rounded knolls, too sterile to grow more than a few small cactus plants (*Opuntia Missouriensis*), rise from the low lands at the bottom of the banks. The valley here has a certain resemblance to the "Bad Lands" of the States to the south-west. This shale is also seen in the higher railway cuttings to the west of Minnedosa. Further south a beautiful section of these shales may be seen in the Pembina valley near La Rivière, on the Pembina Mountain branch of the Canadian Pacific Railway.

Thickness. The total thickness of the Pierre in north-western Manitoba is 800 feet or more. The Millwood series, as seen in the valleys on the northern face of Riding Mountain, has a thickness of between 450 and 500 feet, while about 300 feet of the overlying Odanah series is there also seen, reaching to near the summit of the mountains, and being immediately overlain by the drift deposits. The top of the Odanah series is not seen.

At the village of Deloraine, in south-western Manitoba, and close to the northern face of Turtle Mountain, the tank well on the Pembina Mountain branch of the Canadian Pacific Railway strikes the Odanah shales at a depth of about ninety feet, and a deep well close by it does not strike the Niobrara until a depth of 1,050 feet is reached, giving a thickness for the Pierre of 960 feet. At the foot of Turtle Mountain, a horizontal band of hard gray calcareous sandstone crops out, and assuming this to represent the base of the Laramie, though no fossils have yet been recognized from it, the whole thickness of the Pierre would be given as a little more than 1,050 feet. Considering the Millwood series as having a thickness of 650 feet, a thickness of about 400 feet would remain for the Odanah series.

PLEISTOCENE.

Post-Cretaceous erosion. At the close of the Cretaceous epoch, north-western Manitoba rose above the sea which had covered it since Dakota times, and which had left it mantled with a great series of sands and clays. A period of denudation then set it and continued throughout the whole of the Tertiary epoch. During this time the high table land of the Duck and Riding mountains was cut through by the valleys of the

Red Deer, Swan and Valley rivers, and the great valley of the Winnipeg basin, extending from the Manitoba escarpment to the Archæan nucleus, was formed by a river which may have been similar in size and character to the Mississippi of to-day. From this valley the Cretaceous rocks were almost entirely denuded down to the underlying floor of Palæozoic limestones. The trend of the afferent valleys, and the positions of the points of Cretaceous rocks on the edge of the escarpment, would appear to indicate that the main stream flowed north-westward.

Such was the shape of the country at the beginning of the Glacial period, when a great snow-field appears to have formed on the country around and to the north and east of Reindeer Lake, and the ice appears to have flowed in great glaciers westward through the basin of Lake Athabasca, southward across the plains, and south-eastward up the valley of the ancient river of the Winnipeg basin.

Glacial striæ.

Among the evidences of the course followed by this glacier, or these glaciers, across the region under consideration, the following list of glacial striæ is particularly important. Most of these are strongly marked on the highest parts of level polished surfaces of Palæozoic limestone, and the direction of glacial movement is often shown by curved chatter-marks and cross fractures, &c.

Fairford	S. 33° E.
Flat Rock Bay, Lake Manitoba	S. 10 E.
Steep Rock Point, Lake Manitoba	S. and S. 13 E.
Little Sandy Point, Lake Manitoba	S. 10 E. and S. 10 W.
Onion Point, Lake Manitoba	S.
Granite Island, Lake St. Martin	S. 33 E.
South end Lake Winnipegosis, near Meadow Portage	S. 63 E.
South end Lake Winnipegosis, near Mossy River	S.
Charlie Island, north end, Lake Winnipegosis	S. 2 E.
Charlie Island, east side, Lake Winnipegosis	S. 8-13 E.
Charlie Island, (obscure,) Lake Winnipegosis	S. 37 W.
Weston Point Island, Lake Winnipegosis	S. 2 E.
South Manitou Island, Lake Winnipegosis	S. 12 W.
Lat. 52° 45′, E. side Lake Winnipegosis	S. 9 W.
Long Point, Lake Winnipegosis, several places	S. 22 W.
Long Point, Lake Winnipegosis, one place	S. 8 E.
Ami Island, Lake Winnipegosis	S. 23 W.
S.W. side Cameron Bay, Lake Winnipegosis	S. 43 W.
Rowan Island, Dawson Bay, Lake Winnipegosis	S. 42 W.
Beardy Island, Dawson Bay	S. 58 W.

Rose Island, Swan Lake ..... S. 48-53 W.
McKay Island, Swan Lake and islands to the south ..... S. 53 W.
Red Deer River, ½ mile below Upper Salt Spring ..... S. 78 W.
Red Deer River, Upper Salt Spring ..... S. 68 W.
Red Deer River, Pelican Rapids ..... S. 78 W.
Saskatchewan River, Grand Rapids, bottom ..... S. 2 W.
Saskatchewan River, Grand Rapids, middle ..... S. 62 W.
Saskatchewan River, Grand Rapids, middle (second set.), .. S. 92 W.
Saskatchewan River, below Roche-rouge ..... S. 12 W.
Saskatchewan River, Roche-rouge ..... S. 12 W.
Cedar Lake, south-east shore ..... S. 19 W.
Cedar Lake, Island east of Rabbit Point ..... S. 18 W.
Cedar Lake, mouth of Saskatchewan River ..... S. 39 W.
Cedar Lake, mouth of Saskatchewan River, one groove .... S. 65 E.
Assiniboine River, Sec. 16, Tp. 25, R. 29, on boulders in boulder pavement ..... S. 73 E.

The surface is very generally covered with till, which on the lacustral plain, over the hard Palæozoic limestones, does not appear to be anywhere of great depth; but on the summit of the Cretaceous plateau to the west, where the rocks consist entirely of soft shales, the till would seem to be very much deeper. In most places it immediately overlies the Cretaceous shales, but in some excellent exposures on Rolling River it is seen to be underlaid by seventy feet or more of stratified sands and clays which are probably of Interglacial age. The clays contain the following species of plants and freshwater shells: — Interglacial beds.

Diatomaceæ.

Navicula lata.
Encyonema prostratum.
Denticula lauta.
Licmophora?
Cocconeis.

Phanerogamæ.

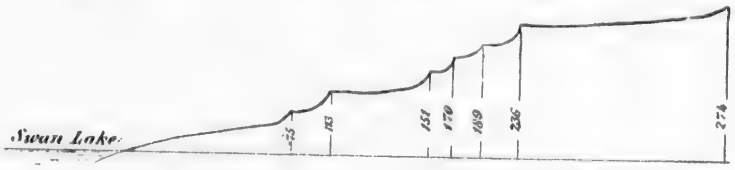
Taxus baccata. L.
Seeds of a Conifer.
Elodea Canadensis (?) Michx.
Vallisneria (?)

Mollusca.

Lymnæa catascopium? Say. Variety with very short spire.
Valvata tricarinata, Say., and a keelless variety.
Amnicola porata? Say.
Planorbis bicarinatus, Say.
" *parvus?* Say.
Pisidium abditum, Haldeman.
Sphærium striatinum, Lamarck.

Lake shores.

On the summit of the Cretaceous plateau the till is covered in a number of places by lake deposits, and east of the escarpment the ancient beaches of Lake Agassiz form long lines of parallel gravel ridges. In some places the ancient lake shores are represented by terraces, cut in the glacial or Cretaceous deposits. An interesting series of these terraces may be seen on the north side of Kettle Hill, south of Swan Lake, as shown in the following figure:—



Section of Kettle Hill South of Swan Lake.
Horizontal Scale · 3000 ft. to an inch.
Vertical Scale · 300 ft. to an inch.

A small amount of lacustral sand and clay is occasionally present on the surface, but as a rule, throughout the greater portion of this district, the old lake floor is composed of till.

Moraines.

Moraines are also present at the Mossy Portage and on and around the "mountains," and will be found more particularly described in the descriptive portion of this report.

The glacial and post-glacial deposits of this region will, however, be more fully discussed in the forthcoming report on Lake Winnipeg.

ECONOMIC GEOLOGY.

Brine springs.

Salt.—The presence of brine springs is a well-marked feature of the Devonian area west of Lakes Winnipegosis and Manitoba; but while the most copious supply of brine flows from the Devonian rocks, chiefly marking the base of the Upper Devonian, salt is not absent from the beds of Silurian age, and many slabs of this rock were found showing beautiful moulds of typical crystals of Chloride of Sodium. A few small springs of clear salty water were found flowing from the Silurian area on the west side of Winnipegosis. Careful search was made everywhere for indications of the presence of beds of pure salt, but none were found, and instead, impressions of salt crystals were common in all the more porous dolomites. It is probable, therefore, that the salt occurs entirely in more or less isolated crystals scattered throughout the rock, but in some cases these are so numerous that at least a third of the whole mass has been salt.

Localities.

The following are some of the principal places where brine springs have been observed:—

1. Salt Creek, west of Lake Dauphin.
2. Banks of Mossy River.
3. Salt Point, south end Lake Winnipegosis.
4. Monkman's Salt Springs, Red Deer Peninsula.
5. Pine Creek.
6. Pelican Bay, mouth of Pelican Creek.
7. " " west side.
8. Mouth of Bell River.
9. Salt Point.
10. Salt Point Peninsula, wide salt area near its base.
11. Salt Point Peninsula, north side of its base.
12. Mouth of Steep Rock River.
13. Lower Red Deer River, many places.
14. Banks of Shoal River.
15. Mouth of Swan River.

Character of saline areas.

At many other places near the line of the base of the Upper Devonian, small saline areas occur, where the brine oozes up through the overlying drift. The characters of these saline areas are very similar throughout, and the descriptions already given of those on Pelican Bay and other places might suffice for all. They are generally barren tracts several acres in extent, surrounded by a fringe of the red salt plant (*Salicornia herbacea*). Here and there springs bubble up and often build rounded mounds of reddish scinter, several feet in height, in the centre of the tops of which, over the springs, are little basins of clear brine. Down the sides of these mounds the water trickles

to the arid flats, where it evaporates in the dry seasons. In other places the pool of salt water is in the middle of a little tract of soft mud, over which may be a sod of coarse grass. In the pool bubbles of gas are constantly rising. This gas was found to be uninflammable, and was probably to a large extent composed of air.

Some of the springs mentioned above were used for the manufacture of salt in the early days of the Red River Settlement, and even yet the Indians occasionally boil down a little salt from them.

Monkman's Salt Works in 1858.

The following excellent description of Monkman's Salt Works, as they existed in 1858, is given by Prof. H. Y. Hind :—*

"The soil at the Salt Springs is a very retentive yellowish white clay, containing small limestone boulders and pebbles, with boulders of the unfossiliferous rocks. The wells, for obtaining a supply of brine, are sunk wherever a small bubbling spring is observed to issue from this retentive clay. The springs are constantly changing their position, and as the wells become exhausted from time to time, a fresh excavation is made where a new spring is observed to issue. No doubt boring, or deeper wells, would prevent these changes, and not only secure a larger flow of brine, but ensure it permanency. The wells at present are 25 in number; but some of them appear to have been lately abandoned, and others have long since ceased to yield brine. They are situated 400 yards from the shore, and were first worked 40 years since, by James Monkman. This enterprising individual struggled for many years against the importation of English salt, which was sold in the settlements at a cheaper rate than he could afford to manufacture salt on Lake Winnipegosis. He has made salt at Swan River and Duck River. The manufacture is now carried on with profit for the Hudson's Bay Company, at Swan River, and at Winnipegosis Lake by Monkman's sons.

"At the 'Works' there are two small log-houses and three evaporating furnaces. The kettles, of English construction, are well made rectangular vessels of iron, five feet long, two feet broad and one foot deep. They are laid upon two rough stone walls, about twenty inches apart, which form the furnace. At one extremity is a low chimney. The whole construction is of the rudest description; and at the close of the season the kettles are removed, turned over, and the furnace permitted to go to ruin, to be rebuilt in the following spring.

"The process of making salt is as follows: When a spring is found, a well, five feet broad and five feet deep, is excavated, and near to it an evaporating furnace erected. The brine from the wells is ladled into the kettles, and the salt scooped out as it forms, and allowed to remain

*Op. cit., pp. 94 and 95.

for a short time to drain before it is packed in birch bark roggins for transportation to Red River, where it commands twelve shillings sterling a bushel, or one hundred weight of flour, or a corresponding quantity of fish, pemican or buffalo meat, according to circumstances.

"The brine is very strong. From one kettle two bushels of salt can be made in one day in dry weather. There are nine kettles at the 'Works,' seven being in constant use during the summer season. The half-breeds engaged in the manufacture complained of the want of fuel—in other words, of the labour and trouble of cutting down the spruce and poplar near at hand, and the difficulty of hauling it to the furnaces. An objection of no moment, but characteristic of some of the people, who are generally unaccustomed to long-continued manual labour. Unfortunately, I had no instrument with me for ascertaining the specific gravity of the brine, and a supply which I took to Red River for that purpose, as well as with a view to its analysis, still remains in the settlements. It will be seen that the processes employed in the manufacture of salt are of the rudest description, so that without any outlay beyond a few days' labour, the quantity might be largely increased. I spoke to John Monkman, who now makes salt here, of pumps and solar evaporation. Of a pump he knew absolutely nothing. He had heard that such an apparatus had been contrived, but had never seen one. He readily comprehended the advantage to be derived from pumping the water into shallow troughs, dug in the retentive clay near the springs, and strengthening the brine by solar evaporation."

Importance of the salt industry to Manitoba.

At the present time the cost of carriage of salt from Ontario renders it very expensive in Manitoba, and the large development of the fishing industry on Lake Winnipeg, and its probable extension to the other lakes of the North-West, renders the question of obtaining an abundant local supply at a reasonable cost one of great importance.

As is shown below the natural brines of Manitoba are not very strong but the supply is large, and the dry climate would be very favourable to their concentration by solar evaporation, which at the same time would remove some of their impurities, and the forests in the immediate vicinity of the springs would furnish an abundant supply of fuel for boiling down the concentrated brine.

Analyses of brines.

Brines were collected from most of the important springs throughout this portion of the country, and have been analysed by Mr. G. C. Hoffmann, of this Survey.* The following table gives in synoptical form the result of his examination :—

*Geol. Sur. Can., Ann. Rep. Vol. V., 1889-90-91, pp. 26 R.—37 R.

ANALYSES OF BRINES FROM MANITOBA.

THE following Table shows the number of grains per Imperial gallon of each of the chief constituents entering into the composition of these Brines.

Constituents.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Chloride of sodium	3426·61	2777·44	3402·5[illegible]	3716·73	3884·57	3673·23	6024·98	3233·15	3709·59	1873·78	1347·08	3099·41
do potassium	163·86	114·59	209·39	180·21	137·90	145·16	86·17	138·81	179·86	150·16	48·72	23·11
do calcium	.....	28·45	.....	.....	.....	7·87	.....	10·43	.....	15 67	.....	44·05
do magnesium	77·17	101·16	101·75	85·69	47·43	94·66	125·46	78·03	81·46	79·84	58·53	142 22
Sulphate of lime	285·83	233·72	296·23	304·96	272·81	300·30	425·25	281·90	398 38	205·53	204·83	252 71
do magnesia	3·42	.....	1·24	6·49	57·30	.....	19·42	.....	10·98	.. ..	10·95	....
Total	3956·89	3255·37	4010·99	4294·08	4400·01	4221·22	6681·28	3742·32	4290·27	2324·98	1670·11	3561·50
Specific gravity	1·039	1·032	1·039	1·041	1·044	1·041	1·063	1·035	1·039	1·022	1·016	1·035

1. Spring on the south bank of Red Deer River, four miles from Lake Winnipegosis. N. lat. 52° 52′ 30″; W. long. 101° 5′. Flow, 10 gallons a minute. Collected, 9th September, 1889.

2. Lower Salt Spring, on the north side of Red Deer River, a mile and three-quarters above its discharge into Lake Winnipegosis. N. lat. 52° 53′ 20″; W. long. 101° 2′ 15″. Flow, 2 gallons a minute. Collected, 13th August, 1889.

3. Spring near the west shore of Dawson Bay, Lake Winnipegosis, three-quarters of a mile north of the mouth of Steep Rock River. N. lat. 52° 48′ 30″; W. long. 100° 57′. Flow, 4 gallons a minute. Collected, 6th August, 1889.

4. Spring on a hillside near the shore of Dawson Bay, Lake Winnipegosis, at a point two miles east of the mouth of Steep Rock River. N. lat. 52° 48′ 30″; W. long. 100° 57′. Flow, 25 gallons a minute. Collected, 8th August, 1889.

5. Salt Point, on the south-west shore of Dawson Bay, Lake Winnipegosis. N. lat. 52° 48′; W. long. 100° 48′. Flow, 1½ gallons a minute. Collected, 3rd August, 1889.

6. Spring on the west side of Dawson Bay, Lake Winnipegosis, three miles and a-half north of the mouth of Bell River, and a mile back from the lake shore. N. lat. 52° 48′; W. long. 100° 51′ 20″. Flow, 20 gallons a minute. Collected, 2nd August, 1889.

7. Brook flowing into the west side of Dawson Bay, Lake Winnipegosis. N. lat. 52° 47′ 40″; W. long. 100° 51′. Flow, 60 gallons a minute. Collected, 1st August, 1889.

8. Spring half a mile back from the west shore of Swan Lake, between it and the lower portion of Swan River. N. lat. 52° 26′ 35″; W. long. 100° 42′ 45″. Flow, 5 gallons a minute. Collected, 31st August, 1889.

9. Spring on the shore of Pelican Bay, Lake Winnipegosis, just east of the mouth of Pelican Creek. N. lat. 52° 38′ 30″; W. long. 100° 21′. Flow, 25 gallons a minute. Collected, 21st July, 1889.

10. Spring on the west side of Pine Creek, near its discharge into Lake Winnipegosis. N. lat. 52° 1′; W. long. 100° 8′. Collected, 6th July, 1889.

11. Monkman's Salt Springs, on the west shore of Lake Winnipegosis. N. lat. 51° 45′; W. long. 99° 56′ 40″. Collected, 1st July, 1889.

12. Monkman's Salt Springs. An old well a few yards from the spring from which No. 11 was obtained. Collected 1st July, 1889.

Speaking of these brines, and of the various methods pursued in the manufacture of salt, Mr. Hoffmann says :—*

"The proportion of foreign saline matters in these brines is not excessive, and if certain purifying processes are had recourse to, there is no reason—local conditions being favourable—why they should not be utilized in the manufacture of salt.

Outlines of methods pursued in the preparation of salt from its solutions.

"The following brief outline of the methods pursued in the preparation of salt from its solutions, will serve to convey some idea of the expedients resorted to for the economical treatment of the weaker salt waters. The processes may be arranged under the following headings : 1. Those in which evaporation is entirely effected by artificial heat : 2. Those dependent upon natural evaporation—either wholly or in part : 3. That in which concentration is effected by congelation—with subsequent recourse to artificial heat.

"1. By artificial evaporation.

Artificial evaporation.

"The manufacture of salt from its solutions by evaporation with artificial heat, is conducted either in large shallow iron pans—as in Cheshire, Worcestershire, and Staffordshire—or in kettles—as at the Onondaga salines and elsewhere. The heating being in both instances effected by fires placed beneath.

Natural evaporation.

"2. By natural evaporation—either wholly or in part.

"(*a*) By the influence of the sun, aided by that of the air—solar evaporation. This method is resorted to in the preparation of salt from sea water, on the shores of the Mediterranean, some parts of the English and Scottish coasts, and in some localities on the Atlantic and Pacific coasts of the United States. The evaporation is carried on in a series of shallow ponds or basins in which the water is spread over a very large surface. These reservoirs, which are excavated on the sea shore, are generally puddled with clay, but on the Bay of San Francisco the better grade of salt is prepared in ponds which are provided with wooden floors, or wholly inclosed with boards, and when a specially pure salt is required, the cleanest of the brine is transferred to, and the evaporation completed in, wooden tanks. When solar evaporation is pursued in the manufacture of salt from natural brines, the process is conducted in a series of shallow wooden vats, arranged in tiers, provided with movable covers running upon rollers for use during rainy weather. The brine is let into the upper tier of vats and from thence is allowed, at different stages of alteration, to pass on until it ultimately arrives—having in the interval deposited and suspended nearly all the less soluble impurities, and lost a large proportion of its water by evaporation—as a clear saturated brine, in the lower tier of vats where the formation of salt goes on.

*Geo. Survey Can., Ann. Rep., Vol. V., pt. R., pp. 36 and 37.

Natural evaporation—*Con.*

"(*b*) By exposure to a current of air—the 'graduation' process. A method employed, among other places, at Montiers in France, and at Nauheim, Dürrenberg, Rodenberg, and Schönebeck, in Germany, in the preparation of salt from weak brines. The process is carried on in what are termed 'graduation-houses.' These are large wooden structures covered over at the top to exclude rain, but left open at the sides to allow of free circulation of air through the building. The interior arrangement may, in a general way, be described as consisting of a large shallow wooden cistern, for the reception of the brine, over which are arranged bundles of brushwood or thorns built up in the form of a wall between wooden supports, and over this a reservoir for the weak brine. The saline water is pumped into the upper reservoir and thence allowed to trickle down over the surface or through the interstices of the thorns, thereby exposing it, diffused over a very large surface, to the influence of the air and effecting its concentration. The operation is repeated as often as may be found necessary for the conversion of the weak into a strong brine.

"The success of these two processes, solar evaporation and 'graduation,' being altogether dependent upon the state of the atmosphere, their use is consequently limited to the more favourable time of the year.

Congelation.

"3. By congelation.

"In some parts of Northern Europe the separation of salt from sea water is, in part, effected by the agency of frost—salt water when partially frozen separating into ice, retaining very little salt, and a proportionately stronger saline liquor. So that by submitting sea water, contained in reservoirs, to repeated partial congelations and removing the ice as it forms, each successive mother liquor becomes more and more impregnated with salt, until at length the solution attains the strength of a saturated brine.

"The process dependent upon evaporation with artificial heat is usually only resorted to in the treatment of strong brines, but where cheap fuel can be obtained the same plan is pursued with the waters of the weaker springs, and sometimes, though rarely, even with sea water. When fuel is scarce the more diluted saline waters cannot be profitably worked in this way, and these can, therefore, only be utilized by resorting to one of the processes of natural evaporation—solar evaporation or that by 'graduation.' The salt may, by either of these methods, be prepared without the aid of artificial heat, as is customary in the preparation of 'bay-salt' and 'solar-salt,' and is also the practice at the 'graduation-works' at Montiers, in France, or the weak brine may be brought to the point of saturation and further evapora-

tion effected with artificial heat. The concentrated liquor obtained by the repeated partial freezing of a weak salt water, is treated as a strong brine, the salt being obtained from it by artificial evaporation."

"*Amber*," or *Chemawinite*.—This interesting mineral was found in pieces from the size of a robin's egg downwards, on sandy beaches on the west side of Cedar Lake, a short distance south of the Saskatchewan river. The shore is low and shelving, and the beach runs along the face of a deep wet spruce swamp, the "amber" being everywhere mixed with many small fragments of partly decayed wood. The swamp behind is stated to be underlaid by a compact till with boulders. "Amber."

The most important beach is a little less than a mile in length, and from 80 to 120 feet in breadth. The "amber" is found most plentifully along its ridge, where it constitutes about ten per cent by volume of the sand and woody debris, and holes dug to a depth of two feet showed little or no diminution in its quantity. A number of samples collected from various parts of the beach showed an average of a little more than ten per cent of "amber," which, in natural fragments, weighed forty-six pounds to the cubic foot. The size of the beach were roughly estimated at 316,800 cubic feet, which would yield about 31,680 cubic feet, or 1,457,280 pounds of "amber." It has probably been washed by the river from some cliff or cliffs of Cretaceous clay or sand higher up the stream, and has been carried down and deposited in the marshy and swampy delta west of Cedar Lake. From this delta deposit, it is now being washed out from time to time by the waves of the lake and thrown up on the beach.

Prof. B. J. Harrington, of McGill College, Montreal, has described this mineral and the following are some extracts from his paper:—*

"The substance was in pieces, for the most part very irregular in shape, some being more or less angular, others approximately spherical, and others flattened, discoid or lenticular. Some of the pieces were smaller than a pea, but they ranged from this up to the size of an ordinary bean (about 2 centimetres long). In colour they varied from pale-yellow to dark-brown, and many, when examined by transmitted light, appeared clouded or banded from the presence of black carbonaceous matter. Superficially they were generally dull, owing, perhaps, to chemical change, but on fresh surfaces the lustre was resinous. The fracture was conchoidal. Though electric on friction, they appear to be less strongly so than ordinary amber. Dr. Harrington's description.

"Light-coloured fragments, free from black carbonaceous matter, were selected for examination, and any superficial crust carefully removed by scraping. The hardness of these selected pieces was fully $2\frac{1}{2}$. The specific gravity, as obtained with a quantity of material in the specific gravity bottle, was 1·055 (at 20°C.), and a single fragment gave by suspension with a hair 1·0543 (20°C). Material selected.

* American Journal of Science, Vol. XLII., Oct. 1891, pp. 332-335.

"The material for analysis was finely powdered and dried over sulphuric acid *in vacuo*. The combustions were made with lead chromate in the usual way, and the ash determined with a separate portion in a platinum crucible.

Results of analyses.

"The following are the results obtained :—

	I.	II.	Mean.
Carbon	80·01	79·91	79·96
Hydrogen	10·37	10·55	10·46
Oxygen	9·53	9·45	9·49
Ash	0·09	0·09	0·09
	100·00	100·00	100·00

Excluding the ash the results become :—

	I.	II.	Mean.
Carbon	80·08	79·98	80·03
Hydrogen	10·38	10·56	10·47
Oxygen	9·54	9·46	9·50
	100·00	100·00	100·00

"The ash was brick-red in colour, and found to contain silica, alumina, iron, lime, and magnesia.

"The only solvents whose action upon the resin has been tried as yet are absolute alcohol and absolute ether, and the effect of these was ascertained as follows :

Action of solvents.

"One gram of the finely powdered resin was mixed with ten grams of pure quartz sand in a cylinder of filter paper and extracted in Soxhlet's apparatus, in the case of the alcohol for three and a half hours (24 siphonings) and in the case of the ether for two hours (24 siphonings). In each case the sand and filter paper were previously extracted by the special solvent for several hours. The extract from the resin was evaporated in a weighed platinum dish and the residue dried at 100°C. The results obtained were as follows :

	Per cent.
Dissolved by absolute alcohol	21·01
Dissolved by absolute ether	24·84

"The effect of more prolonged action of the solvents has not as yet been ascertained. The alcoholic extract after drying was brownish in colour, while that obtained with ether was only faintly yellow.

"When small fragments of the resin were heated in closed tubes it was found that they began to soften at about 150°C., the point of softening being roughly ascertained by pressure with a platinum rod. At 180-190°C. the fragments were sufficiently yielding to be pressed into one mass by the platinum rod. Heated up to 300°C., the resin did not melt into a flowing liquid, but became soft and elastic, and had darkened a good deal from partial decomposition. Softens with heat.

"Fragments of genuine amber behaved in a similar manner, but began to soften at about 140°C. At 180° they could be readily pressed into one mass, and in the one experiment tried they seemed to darken more readily than the Cedar Lake resin when heated up to 280-300°C. The ordinary statement that amber fuses at 287°C is certainly misleading, the fact being that it begins to soften at a very much lower temperature, gradually getting softer and softer as the temperature rises, but not becoming a flowing liquid until decomposition takes place.

"On heating the Cedar Lake resin in a test tube or retort no crystals of succinic acid were obtained, although they were readily obtained from true amber by similar treatment.

"It is customary to assign to amber the formula $C_{40}H_{64}O_4$, which gives: carbon 78·94, hydrogen 10·53, oxygen 10·53; but this is apparently based upon very insufficient data—so far as the writer is aware, upon the single analysis of Schrotter (carbon 78·82, hydrogen 10·23, oxygen 10·95), which really corresponds much more closely to $C_{39}H_{60}O_4$. Such a substance as amber, too, coming from a variety of localities and originally derived from very different plants can scarcely be expected to agree closely in composition with one definite formula. Formula

"The Cedar Lake resin contains more carbon than the amber analysed by Schrotter and less oxygen, and in this respect comes nearer to Walchowite and to some of the recent copals from India. The relations of some of these bodies will be made plain by the following tables:

—	Carbon.	Hydrogen.	Oxygen.	Ratio of C, H, & O atoms.	Ratio of C, H, & O atoms, taking C = 40.
I. Amber	78·82	10·23	10·95	9·60 : 14·95 : 1	40 : 62·29 : 4·16
II. Krantzite.....	79·25	10·41	10·34	10·22 : 16·11 : 1	40 : 63·05 : 3·91
III. Cedar Lake Resin..	80·03	10·47	9·50	11·23 : 17·63 : 1	40 : 62·79 : 3·56
IV. Copal (Bombay)....	79·70	10·40	9·90	10·75 : 16·83 : 1	40 : 62·62 : 3·72
V. Copal (Calcutta).. .	80·34	10·32	9·34	11·46 : 17·67 : 1	40 : 61·67 : 3·49

I. Phillips's Mineralogy (1852), p. 630. Anal. by Schrotter. II. Dana's Mineralogy (1869), p. 741. Anal. by Landolt. IV. Watts's Dictionary of Chemistry (ed. i.), Vol. II., p. 19. Anal. by Filhol. V. Watts's Dictionary of Chemistry (ed. i.), Vol. II., p. 19. Anal. by Filhol.

"Though resembling amber in some of its characters, the Cedar Lake resin may here be classed provisionally as "retinite," on account of its differing from amber in its deportment with solvents, in not yielding crystals of succinic acid on distillation, and in having a somewhat different ultimate composition. The name retinite as used by some mineralogists is a convenient general term to include such substances as Walchowite, Krantzite, Jaulingite, Rosthornite and the Cedar Lake resin, which last, by way of distinguishing it from other retinites, may be called Chemawinite (from Chemahawin or Chemayin, the Indian name of a Hudson Bay post, not far from where the resin occurs).

Origin.

"Though the origin of this substance is not certainly known, there can be little doubt that it has been derived from one of the Tertiary or Cretaceous lignites occurring on the Saskatchewan. Some of these are known to contain resins, one of which, examined by the writer, was not essentially very different from the Cedar Lake material. It behaved similarly on heating, had a hardness of over 2, a specific gravity of 1·066, and dissolved in absolute alcohol to the extent of 29·30 per cent.

Uses.

"Some of the larger pieces of the Cedar Lake resin might, perhaps, be employed for ornamental purposes (beads, &c.), and possibly the material might be utilized by the varnish-maker."

Nodules of carbonate of iron.

Iron.—Nodules of Carbonate of Iron are present in considerable numbers in the Pierre shales, both on the north side of Riding Mountain and in the banks of the Assiniboine Valley. They were nowhere seen in sufficient quantity to be of any economic importance. A specimen collected by Dr. Bell from the crossing of White Sand River, was found by Mr. G.C. Hoffmann to contain 34·07 per cent of metallic iron.*

Lignite.

Coal.—Lignite was found in the form of carbonized masses of wood or tree trunks, lying in the Benton shale on Swan River, and also in small quantity in the Niobrara shale on Wilson River. The following is a description and analysis by Mr. G. C. Hoffman of a specimen from the former locality :— †

"Lignitified Wood.—From Swan River, Manitoba, township 37, range 26, west of the Principal Meridian.

"Has a clear and wood-like structure ; colour black, with a faint brownish tinge ; lustre dull, that of a freshly fractured surface resinous ; fracture uneven, occasionally sub-conchoidal ; hard and tough ; does not soil the fingers ; powder brownish-black ; it communicates a deep brownish-red colour to a boiling solution of caustic potash ; by exposure to the air becomes fissured.

* Rep. of Prog. Geol. Sur., Can., 1875-6, p. 431.
† Ann. Rep. Geol. Sur. Can., Vol. IV., N.S., 1888-9, p. 6 R.

"Analysis by fast coking gave:—

Hygroscopic water	9·66
Volatile combustible matter	43·16
Fixed carbon	43·61
Ash	3·57
	100·00
Coke, per cent	47·18

"Ratio of volatile combustible matter to fixed carbon, 1 : 1·01. It yields a loose fritted coke; the gases evolved during coking, burnt with a yellowish, somewhat luminous, slightly smoking flame. The ash has a pale brownish-yellow colour, it is readily fusible at a bright red heat, running into a fluid slag."

Similar lignite was found lying in fresh fragments on the shore of Pemmican Island, having been washed up by the waves from a bed beneath the surface of the lake. This bed is doubtless of Cretaceous age, probably at the horizon of the Dakota formation. Gypsum.

Gypsum.—An extensive deposit of gypsum and anhydrite was found in the Silurian area a short distance north-east of Partridge Crop Lake, and a bed of gypsum fifteen feet in thickness was also passed through in the middle of the Upper Devonian limestones at a depth of 560 feet in the deep well on Vermilion River.

Phosphatic Shale.—A small deposit of phosphatic shale, containing a large number of fragments of the bones of fishes, outcrops on the banks of Wilson River in Section 18, township 25, range XX. The bed may be extensive, but at the time it could not be traced for any considerable distance. Mr. Hoffmann found it to contain 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. If the bed proves to be extensive it may be utilized as a fertilizer in the same way as the coprolite beds are used in England and France. Throughout all the Niobrara shales, however, these fish remains are present in small quantities, and add greatly to the richness of the soils formed by their disintegration. Phosphatic shale.

APPENDIX.

List of photographs taken during the course of the explorations in the summers of 1887-90. Uniform size $6\frac{1}{2}$ x $8\frac{1}{2}$ inches.

1887.

1. Valley of the Little Saskatchewan River at Strathclair, Man. July 19.
2. Lake Audet, in the Riding Mountain at the head of the Little Saskatchewan River, Man. July 21.
3. Willow-covered plain by Edward's Creek, Man. July 25.
4. Beach of Lake Dauphin, Man. July 26.
5. Valley River, in Sec. 11, Tp. 24, R. 21, W. Man., looking up the stream. August 8.
6. Valley River, in Sec. 11, Tp. 24, R. 21, W. Man., looking down the stream. August 8.
7. Bank of Drifting River, from gravel ridge east of Duck Mountain, Man. August 9.
8. Face of gravel ridge on north side of Fork River, Man. August 11.
9. "Pitching ridge," north of Valley River, Man. August 16.
10 and 11. Views up and down Valley River from the top of one of the highest of the gravel ridges east of the Duck Mountain. August 18.
12 and 13. Sides of valley of Valley River, Man., showing old Indian houses. August 19.
14. Morainic ridge, two miles below the mouth of Short Creek, on the Valley River, Man. August 20.
15. North end of Shoal Lake, in Tp. 17, R. 23, W. Man. August 26.
16. Noon camp, at the trail crossing of Silver Creek, in Tp. 20, R. 27, W. Man. August 31.
17. Silver Creek, in Tp. 20, R. 27, W. Man. August 31.
18. Village of Russell, Man. September 1.
19. Small lake south of the Angling Lake trail, on Duck Mountain, Man. September 6.
20. One of the Angling Lakes, on Duck Mountain, Man. September 7.
21. Indian Village, near Angling Lakes, Duck Mountain, Man. September 10.
22. Shell River, near trail to Côté's Reserve, Man. September 18.
23. Shell River, in latitude 51° 35′, Man. September 19.
25. Northern Pocket Gopher (*Thomomys talpoides*, Rich.) natural size. Shell River, Man. September 19.
25. Marsh near Fort Pelly, Assa. September 24.
26. Swan River, looking from the Square Plain, Man. September 29.
27. Swan River, from mouth of Oak Creek, Man. October 16.
28. Saulteux Indians from the Upper Assiniboine River. October 16.
29 and 30. Second crossing of Swan River, Man., opposite the old store-house of the H. B. Co. October 18.

31. Poplar forest at second crossing of Swan River, Man. October 24.
32 and 33. Valley of Swan River at the Upper Crossing, north-east of Fort Pelly, Assa. October 30.
34. Swan River, from old Police Barracks, Assa. October 31.
35. Valley of Snake Creek, Assa., looking across. October 31.
36. Valley of Snake Creek, Assa., looking down. October 31.
37. Fort Pelly, Assa. November 1.
38. Stopping Place, on the trail from Russell to Fort Pelly. November 3.
39. Valley of Big Boggy Creek, at the crossing of the Russell and Fort Pelly trail. November 4.

1888.

40. Steep Rock Point, Lake Manitoba. July 1.
41. Camp of Saulteux Indians on the shore of Lake St. Martin, Man. July 4.
42. Chief Wekemowskunk, and family, Lake St. Martin, Man. July 4.
43. Chief Wekemowskunk building a canoe, Lake St. Martin, Man. July 4.
44. Island of red granite in Lake St. Martin, Man. July 4.
45. Waterhen River, Man. July 18.
46. Pile of boulders on Twin Islands, Lake Manitoba. July 18.
47. Monroe Point, Lake Manitoba. July 20.
48. Horse-shoe harbour, Manitoba Island. July 26.
49. Onion Point, Lake Manitoba. August 1.
50. Big Sandy Point, Lake Manitoba. August 2.
51. Small stony island, with young cormorants, Lake Manitoba. August 4.
52. Steep Rock Point, Lake Manitoba. August 5.

1889.

53. Ruins of Old Trading Post, near the Narrows of Lake St. Martin, Man. June 7.
54. Narrows of Lake Manitoba, west side. June 12.
55. Harbour on Cherry Island, Lake Manitoba. June 14.
56. Mossy River, near the mouth. June 22.
57. and 58. Cliff of limestone on Mossy River, just above the old C. P. R. crossing. June 23.
59. Fork River, looking eastward towards Mossy River. June 25.
60. Cliff of till and alluvial clay on Mossy River, just below Fork River. June 29.
61. View down Mossy River, from near the same point. June 29.
62. Brine spring at "Monkman's Salt Springs," Lake Winnipegosis. July 1.
63. Well and ruins of old house on arid flat at "Monkman's Salt Springs." July 1.
64. Glaciated surface of limestone on island off Weston Point, Lake Winnipegosis. July 2.
65. Cliff of Manitoban limestone on Island off Weston Point. July 2.
66. Limestone Cliffs at Point Brabant, Lake Winnipegosis. July 4.
67. Point Brabant, Lake Winnipegosis, showing row of elm trees in front of the cliff. July 4.
68. Sloping beach of gravel shoved up by the ice, north-west point of Birch Island, Lake Winnipegosis, July 13.
69. Low cliff of limestone at the north end of Birch Island, Lake Winnipegosis. July 13.
70. Cliff of dolomite hidden among the trees at the north end of Hill Island, Lake Winnipegosis. July 13.

71. Cliff of till 100 yards south of the north point of Hill Island, Lake Winnipegosis. July 13.
72. Our boat off beach of boulders, at the north end of Birch Island, Lake Winnipegosis. July 14.
73. Boulder wall, fifteen feet high, at the north-east end of North Manitou Island, Lake Winnipegosis. July 15.
74. Cliff of nodular dolomite at Devil's Point, Lake Winnipegosis. July 18.
75. Cormorants and pelicans on Cormorant Islands, Lake Winnipegosis. July 18.
76. Groove, ten paces long, in the mud and gravel on the beach, with boulders lying in the upper end of it. Looking S. 25° E., Pelican Bay, Lake Winnipegosis. July 20.
77. Same groove. Looking N. 25° W.
78. Boulder lying at the upper end of a long grove, with clay and irregular pebbles shoved up in front of it. Pelican Bay, Lake Winnipegosis. July 20.
79. Two boulders, lying at the end of a groove twenty-five paces long which runs N. 30° W. through the mud and stones of the beach. Looking south. Pelican Bay, Lake Winnipegosis. July 21.
80. Large boulder on the west shore of Pelican Bay, Lake Winnipegosis. July 22.
81. Irregular nodular limestone shoved up on the beach by the ice. Channel Island, Lake Winnipegosis. July 23.
82. Cliff of Manitoban limestone among the trees in Cameron Bay, Lake Winnipegosis. July 23.
83, 84, 85. Cliff of Dolomite at the base of the Stringocephalus zone on island north of Whiteaves Point, Lake Winnipegosis. July 25.
86. Rocky hill on north end of island west of Whiteaves Point, Lake Winnipegosis. July 29.
87. Large boulder on same island.
88, 89, 90. Swampy Crees in camp at Shoal River, Man. July 30.
91. High beach of rounded pebbles at south end of island off Salt Point, Lake Winnipegosis. August 3.
92. Cliff at Point Wilkins, showing sandstone included in the fragmentary limestone. August 6.
93. Inclusion of sandstone in the broken limestone at Point Wilkins, Lake Winnipegosis. August 6.
94. Cliff of limestone rising forty feet above the water just south of Point Wilkins. August 6.
95. Cliff of thick bedded limestone opposite the mouth of Steep Rock River, Lake Winnipegosis. August 7.
96. Cliff of limestone four miles east of Steep Rock River, Lake Winnipegosis. August 9.
97. Point Wilkins at the buttress and cave. August 9.
98. Point Wilkins from Small Island. August 9.
99. Point Wilkins, showing disturbed beds of limestone. August 9.
100. Point Wilkins looking westward. August 9.
101. Cliff of dolomite at point three miles north of Red Deer River, Lake Winnipegosis. August 12.
102. Cliff of dolomite at point five miles north of Red Deer River. Lake Winnipegosis. August 12.

103. Cliff of dolomite at south end of Rowan Island, Lake Winnipegosis. August 12.
104. View up Red River Deer, Saskn., from its mouth. August 13.
105. Lower Salt Spring, Red Deer River, Saskn. Looking eastward down the stream. August 13.
106. Cliff of sloping limestone on Red Deer River, Saskn., a short distance above the Lower Salt Springs. August 13.
107. Glaciated surface of limestone at Rowan Island, Lake Winnipegosis. August 14.
108. North shore of Lake Winnipegosis at the Western Mossy Portage. August 16.
109. Cast of large orthoceratite in cliff of Winnipegosan dolomite, Whiteaves' Point, Lake Winnipegosis. August 17.
110. Shoal River House, H. B. Co., looking towards Swan Lake. August 21.
111. Shoal River House, H. B. Co., looking along the shore.
112. Cliff of Manitoban limestone at the east point of Rose Island, Swan Lake, Man. August 22.
113. Glaciated surface of limestone on Two Islands, Swan Lake, Man. August 24.
114. Birch River, Man., looking up stream from two miles above its mouth. August 25.
115. Indian Camp on the north side of Birch River, Man. August 25.
116. Site of the Hudson's Bay Company's old trading post at the Lower Crossing of Swan River, Man. August 29.
117. Swan River, Man., looking down the stream from the site of the old Trading Post. August 29.
118. Rocky hill, south of Swan River, at the north-east end of the trail. August 30.
119 and 120. Rounded bosses of Dakota Sandstone on a terrace on the side of Kettle Hill, south of Swan Lake, Man. September 3.
121. Boulder pavement on the south shore of Red Deer Lake. September 12.
122. Site of old Trading Post of Hudson's Bay Company on the south side of Red Deer River, just west of Red Deer Lake. September 14.
123. Red Deer River, Saskn., from same place. September 15.
124. Site of old Trading Post of the North-west Company on the north side of Red Deer River. September 15
125. Hartmann's Trading Post at Pine Creek, Lake Winnipegosis, Man October. 8.
126. Hartmann's Trading Post at Waterhen River, Man. October 13.

1890.

127. Assiniboine River, Man. Below the mouth of Little Boggy Creek. June 19.
130. Site of old Trading Post of the North-west Company (Grant's House) in the bottom of the Assiniboine Valley. June 19.
131. Bottom of Assiniboine Valley, a short distance further down. June 20.
132. Assiniboine River, near Beulah, Man. June 29.
133. Valley of the Assiniboine from the side of the hill below the site of Boss Hill Fort, north of Virden, Man. July 2.
134 and 135. Assiniboine River, at bridge north of Griswold, Man. July 4.
136 and 137. Lake Clementi, Brandon Hills, Man. July 6.
138. Assiniboine River, near the mouth of Little Souris River, Man., showing cliffs of sand and gravel. July 8

139. View across the Assiniboine River towards the sand hills, from the site of the old fort above the mouth of Souris River. July 9.
140 and 141. Assiniboine River, at the outcrop of Niobrara limestone and shale below the mouth of Cypress Creek. July 13.
142 and 143. Old Trading Post of the Hudson's Bay Company at Portage la Prairie, Man. July 15.
144. Steamer "Red River," on Lake Winnipeg. July 24.
145. Old Trading Post of the Hudson's Bay Company near the north end of the Tramway at Grand Rapids, Saskatchewan River, Saskn. July 26.
147. Roche Rouge Point, Saskatchewan River, Saskn. July 27.
148. Island, near the Narrows of Cedar Lake, Saskn. July 31.
149. Rabbit Point, Cedar Lake, Saskn. August 1.
150. North-east side of Fort Island, Cedar Lake, Saskn. August 5.
151. North-west side of Fort Island, Cedar Lake, Saskn. August 5.
152 and 153. Cliffs of Niagara limestone on the south-west shore of Cedar Lake, Saskn. August 8.
154. Trading Post of the Hudson's Bay Company at the south end of the Grand Rapids, Saskatchewan River. August 11.
155. Another view of the same. August 14.
156. Saskatchewan River, looking up the stream from Grand Rapids Post towards Potato Island and the foot of the Grand Rapids. August 14.
157. Camp of Geological Survey party, and detachment of North-west Mounted Police at Grand Rapids. August 14.
158. Grand Rapids, Saskatchewan River. Looking up stream from the lower end of the old portage; showing vertical cliff of Niagara dolomite. August 14.
159 Grand Rapids, Saskatchewan River. Another view from a little higher up the stream.
160. Grand Rapids, Saskatchewan River. Looking down stream from the lower end of the old portage.
161. Grand Rapids, Saskatchewan River. Looking across to vertical cliffs on opposite side of river.
162. Grand Rapids, Saskatchewan River. Looking down the gorge from the head of the rapids.
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